5.3.3 Turning Movement Survey

The turning movement survey for this study is important for providing details on the directional movements of traffic. The intersections where this survey was executed are shown in Fig. 5.4, with the survey sheet shown in Tab. 5.5. The details of its execution are as follows:

- Survey Time: Morning peak and off-peak times over a period of 3 days.
- Measurement Intervals: 15 minutes.
- No. of Survey Stations: 16 stations representing major junctions in the CMR.
- Vehicle Class: 8
- Survey Methodology: Measurements were carried out for all the directions of travel (left, right, straight) by a single team of enumerators that did a 15-minute count for each

5.3.4 Travel Speed Survey

This survey is important in that it provides observed travel speed data that can be directly compared with modeled travel speeds in the calibration of the traffic demand model. The routes where this survey was carried out are as shown in Fig. 5.5, with the survey sheet shown in Tab. 5.6.

- Survey Time: Morning peak and off-peak times over a period of 3 days.
- No. of Measurements: 2 times per day for the 8 survey routes for both directions, with speeds recorded at the appropriate locations along each route.
- Survey Methodology: A test car was used and average travel speeds for the different locations along the survey routes obtained by travelling along with the traffic flow (i.e., the average car method was applied).

5.3.5 Bus Passenger Interview Survey

This survey, like the bus passenger volume survey, was a supplemental survey and not initially considered. The importance of this survey is to determine whether bus riders are captive users for modal split purposes. The locations where the survey was executed are shown in Fig. 5.6, with the survey sheet shown in Tab. 5.7. The details of the survey execution are as follows:

- Survey Time: Depending on whether or not there was existing data, either a 6 hour survey (morning or afternoon) or an all-day survey was carried out. Also, at important bus locations, the all-day survey was done for 3 days.
- Survey Items: Access mode, egress mode, and car ownership.
- Survey Methodology: Bus passengers waiting at important bus stops and terminals were interviewed at random and their answers recorded on site.

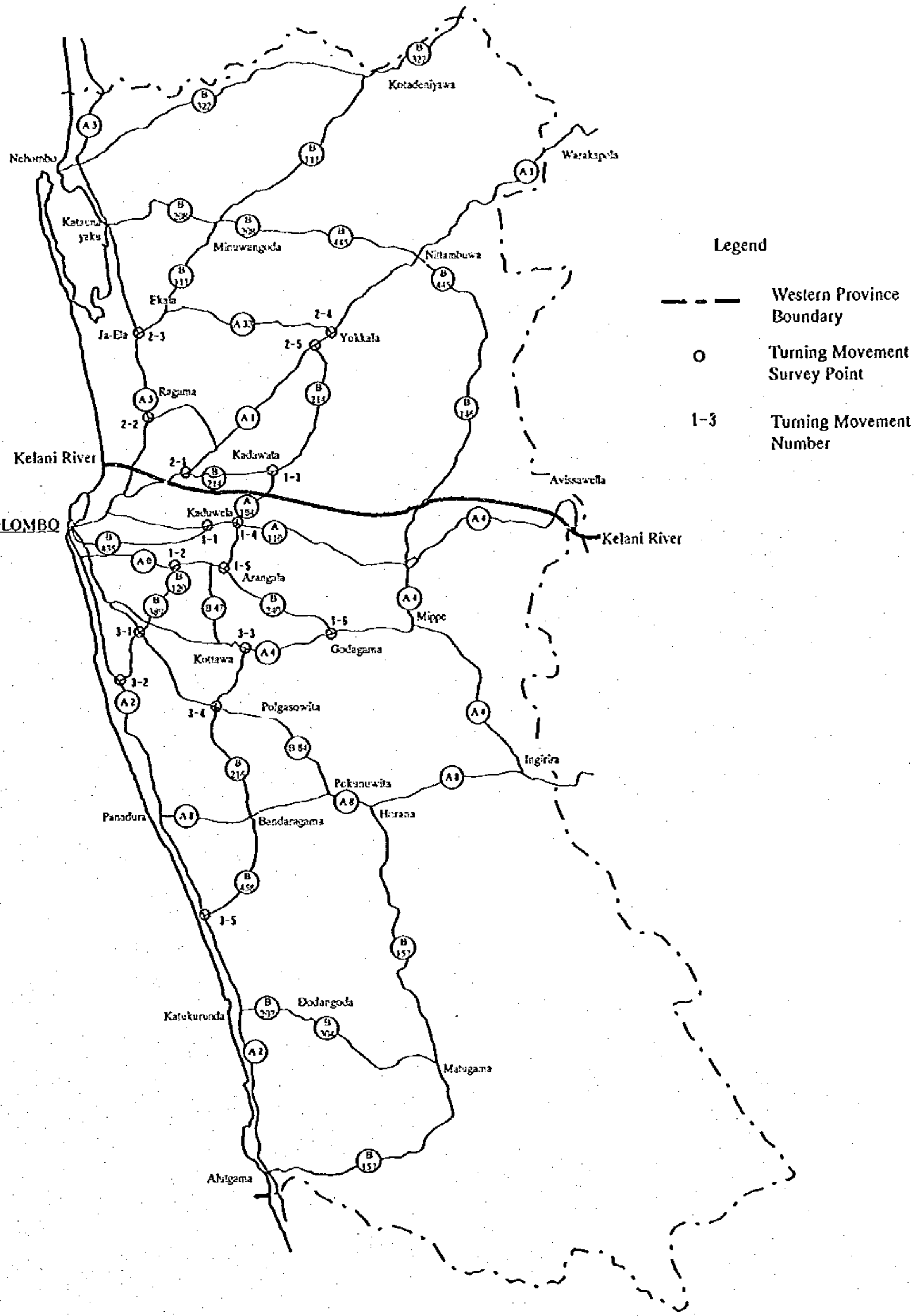


Fig. 5.4 Turning Movement Survey Points

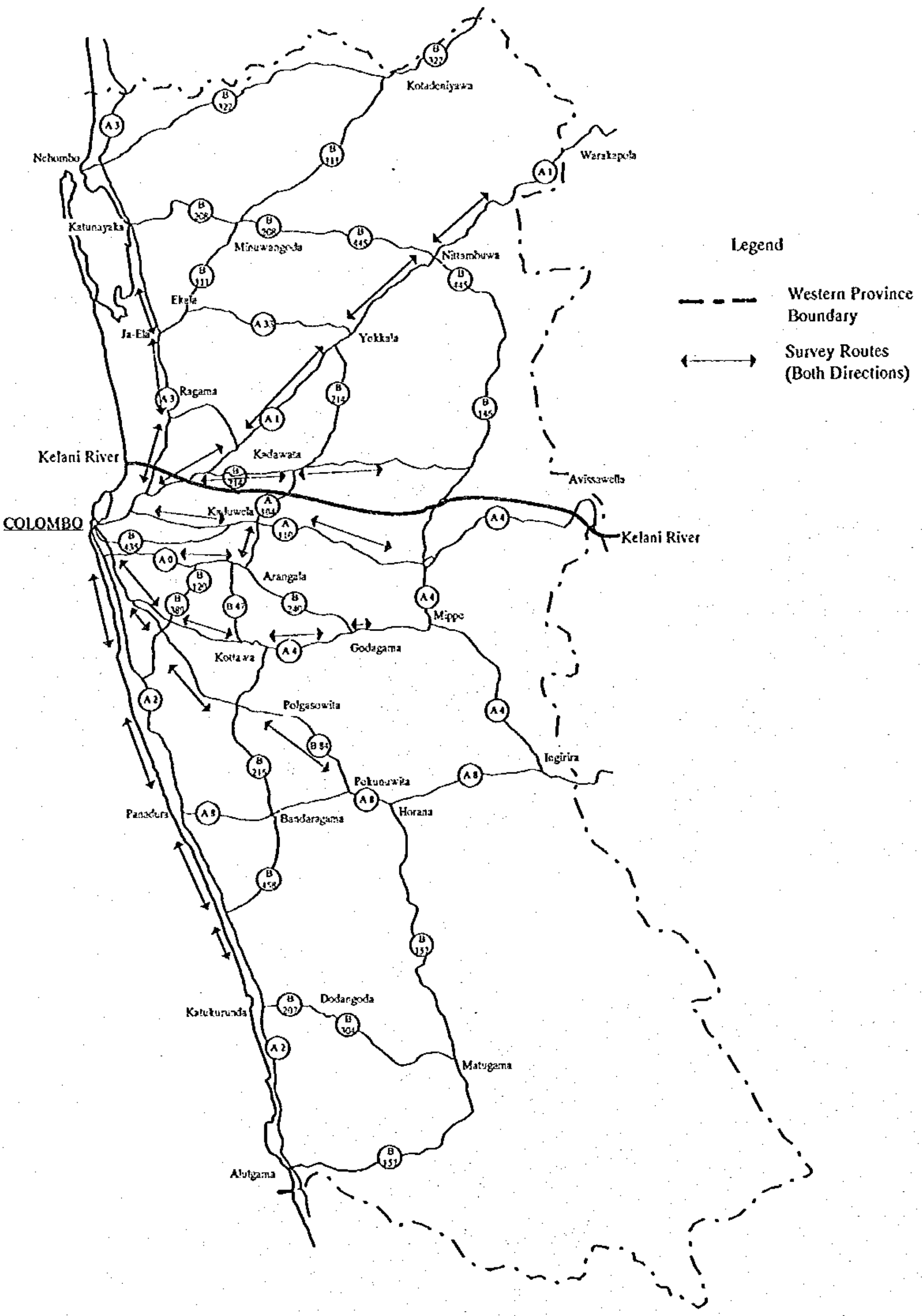


Fig. 5.5 Travel Speed Survey Routes

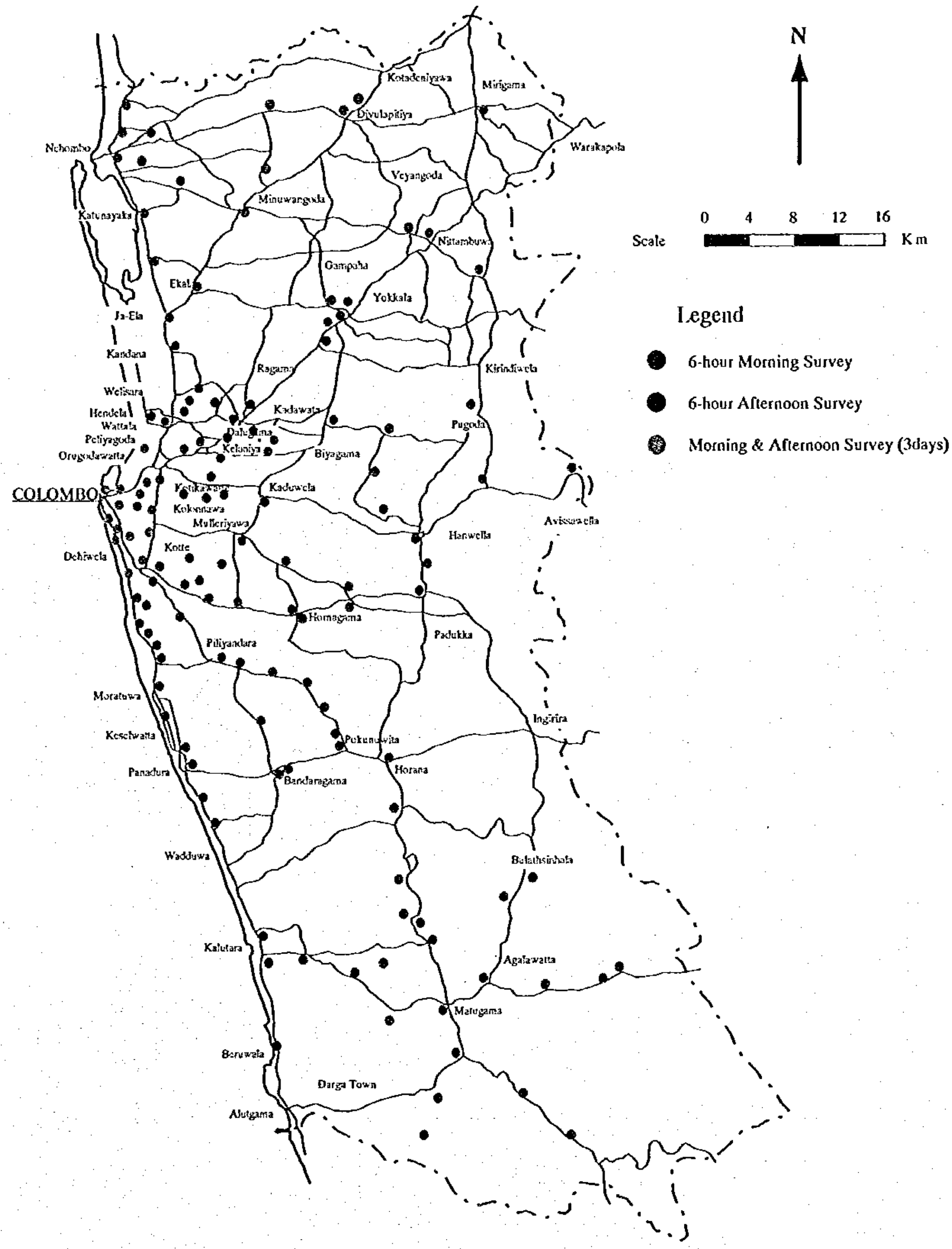


Fig. 5.6 Bus Passenger Interview Survey Locations

Tab. 5.5 Turning Movement Survey Sheet

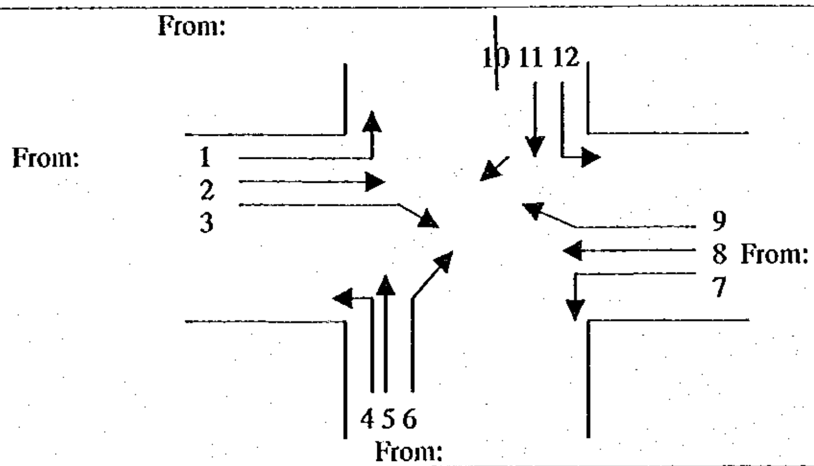
Name of Observer(s):

Date:

Day:

Weather: Dry ☐ Wet ☐

Movement No.: 1



Time	No. of Vehicles by Type							
	Pass. Car	3-wheeler	Motorcycle	Minibus	Bus	Truck	Large Truck	Farm Vehicle
7:00 – 7:15								
8:00 – 8:15								
9:00 – 9:15								
10:00 –10:15								
11:00 – 11:15								
12:00 – 12:15								
13:00 – 13:15								
14:00 – 14:15								
15:00 – 15:15								
16:00 – 16:15								
17:00 – 17:15								
18:00 – 18:15								

Tab. 5.6 Travel Time Survey Sheet

Name of Recorder(s):

Location:

Direction: From:........................ To:...............................

Route Name:

Date:

Day:

Run:

Time Start:................. A.M./P.M.

Junction Name	Cumulative Sect. Length (km)	Cumulative Travel Time (min:sec)	Special Notes	Sect. Travel Time

Tab. 5.7 Bus Passenger Interview Sheet

Name of Recorder(s)			Location		Date & Day		Direction To:........................ From:......................	Time:	
	Origin			Destination					
Route # Name	Zone	Place	Access Mode	Zone	Place	Egress Mode		Do you have a car available for your personal use?	If yes, why do you use the bus?
....	1. Village/Town .... 2. DSD .... 3. District/Prov.	1. Home 2. Work 3. School/Ed. 4. Business 5. Social	1. Walk 2. Bike/M'bike 3. Bus 4. Rail 5. Car/Van 6. 3 W/Taxi	1. Village/Town .... 2. DSD .... 3. District/Prov.	1. Home 2. Work 3. School/Ed 4. Business 5. Social	1. Walk 2. Bike/M'bike 3. Bus 4. Rail 5. Car/Van 6. 3 W/Taxi		1. Yes 2. No	1. Cheaper 2. Faster 3. More Convenient 4. All of the Above
....	1. Village/Town .... 2. DSD .... 3. District/Prov.	1. Home 2. Work 3. School/Ed. 4. Business 5. Social	1. Walk 2. Bike/M'bike 3. Bus 4. Rail 5. Car/Van 6. 3 W/Taxi	1. Village/Town .... 2. DSD .... 3. District/Prov..	1. Home 2. Work 3. School/Ed 4. Business 5. Social	1. Walk 2. Bike/M'bike 3. Bus 4. Rail 5. Car/Van 6. 3 W/Taxi		1.Yes 2..No	1. Cheaper 2. Faster 3. More Convenient 4. All of the Above
....	1. Village/Town .... 2. DSD .... 3. District/Prov.	1. Home 2. Work 3. School/Ed. 4. Business 5. Social	1. Walk 2. Bike/M'bike 3. Bus 4. Rail 5. Car/Van 6. 3 W/Taxi	1. Village/Town .... 2. DSD .... 3. District/Prov.	1. Home 2. Work 3. School/Ed. 4. Business 5. Social	1. Walk 2. Bike/M'bike 3. Bus 4. Rail 5. Car/Van 6. 3 W/Taxi		1.Yes 2..No	1. Cheaper 2. Faster 3. More Convenient 4. All of the Above
....	1. Village/Town .... 2. DSD .... 3. District/Prov.	1. Home 2. Work 3. School/Ed. 4. Business 5. Social	1. Walk 2. Bike/M'bike 3. Bus 4. Rail 5. Car/Van 6. 3 W/Taxi	1. Village/Town .... 2. DSD .... 3. District/Prov.	1. Home 2. Work 3. School/Ed. 4. Business 5. Social	1. Walk 2. Bike/M'bike 3. Bus 4. Rail 5. Car/Van 6. 3 W/Taxi		1.Yes 2..No	1. Cheaper 2. Faster 3. More Convenient 4. All of the Above

5.3.6 Traffic Survey Results & Analyses

Traffic survey results and their analyses are discussed below. For detailed traffic survey data, refer to Annex I (Traffic Survey Data & Traffic Model Results).

1) Roadside OD Survey

Sampling Rate

The number of vehicles that were sampled and the sampling rates for the 16 OD survey points illustrated in Fig. 5.3 are noted in Tab. 5.8. As Tab.5.8 indicates, the average sampling rate for passenger vehicles was 13.5% and for freight vehicles 29.6%. The goal was to achieve a sampling rate of 10%. Although this was realized on average, it was not possible to achieve this at all the sites due to reasons such as lack of police staff, bad weather, and difficulties in stopping vehicles at highly congested locations. However, except for the passenger vehicle OD survey at Site 4, the sampling rates generally seem to be sufficient.

Tab. 5.8 OD Survey Sampling Rates (12 hours)

Site	Total No. of Pass. Veh. Sampled	Sampling Rate for Pass. Veh.	Total No. of Freight Veh. Sampled	Sampling Rate for Freight Veh.
1	1035	3.1%	742	11.5%
2	892	4.4%	324	9.5%
3	712	8.7%	489	26.9%
4	916	2.2%	281	19.7%
5	1345	6.0%	438	47.5%
6	1345	8.0%	366	43.5%
7	830	3.1%	385	11.6%
8	413	7.2%	255	15.0%
9	111	4.4%	142	12.8%
10	496	16.9%	428	29.3%
11	520	6.4%	423	15.3%
12	580	19.8%	485	21.3%
13	549	34.0%	458	25.6%
14	554	43.3%	169	100.0%
15	720	33.8%	572	68.5%
16	905	14.4%	549	34.1%
Average		13.5%		29.6%

Vehicle Trip Characteristics

Passenger vehicle trips by purpose were categorized into 3 types: home-based work trips, home-based other trips, and non-home-based trips. As Fig. 5.7 indicates, home-based other trips accounted for the largest proportion of trips at approximately 44%, with home-based work trips being next at 33% and non-home-based trips the smallest at 23%. Note that school trips are included in home-based other trips.

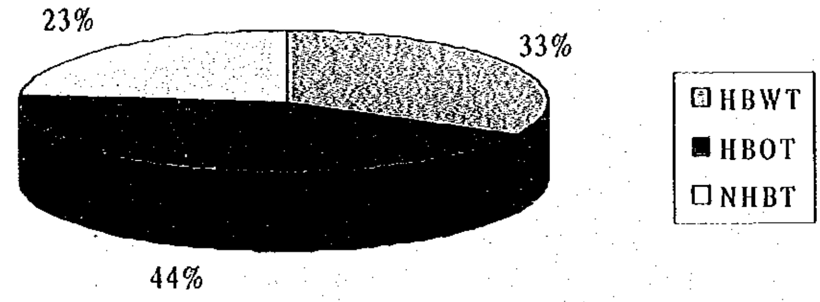


Fig. 5.7 Vehicle Trip Composition by Purpose

As for freight vehicle trips, excluding those trucks that were empty (36%), the most ferried items according to those vehicles surveyed were construction materials (18%), industrial products (17%), and processed food (12%). The proportion of vehicles that were carrying other types of commodities totaled about 17%.

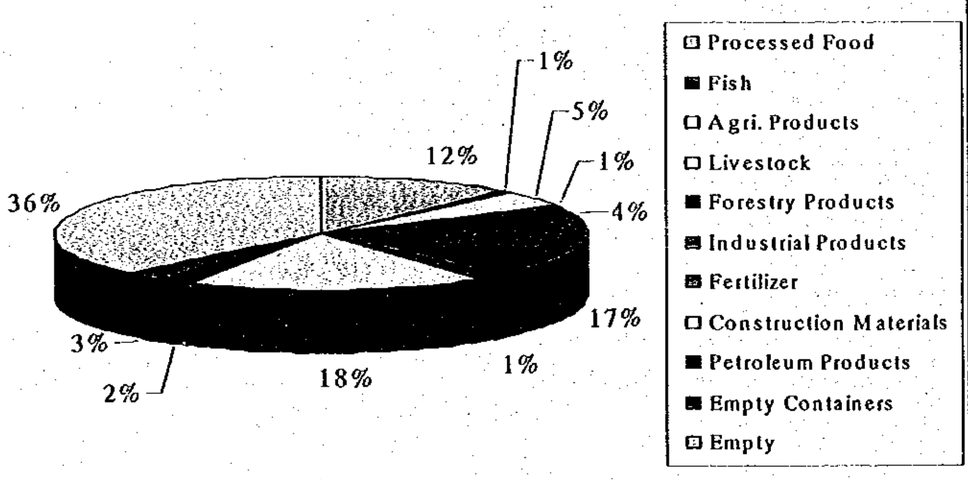


Fig. 5.8 Commodities Carried by Freight Vehicles

As for total vehicle trip movements, Fig. 5.9 indicates that the vast majority of vehicles surveyed (or 87.1%) traveled within the CMR. As for vehicle trips with one trip end outside of the CMR, these accounted for 12.6% of the vehicles surveyed, while only 0.4% of the vehicles questioned were through trips.

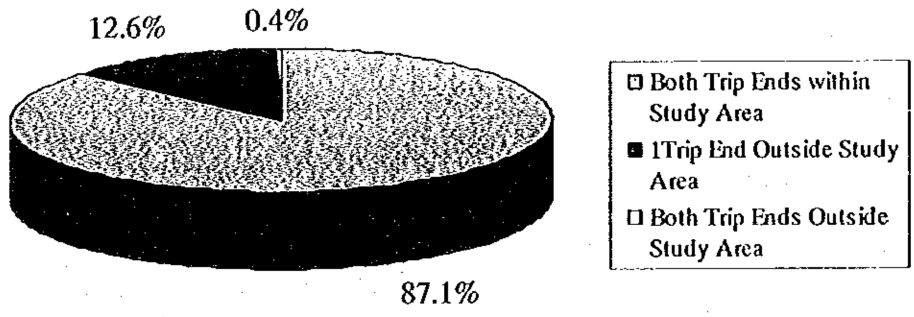


Fig.5.9 Outline of Vehicle Trip Movements

Establishment of OD Tables

Daily OD tables for freight vehicles and for the above-mentioned trips purposes for passenger vehicles were prepared with the assistance of the University of Moratuwa's Dept. of Civil Engineering (Transportation Engineering Div.). The process used to construct daily OD tables is shown in Fig. 5.10. The present OD table (all modes and all purposes) is shown in Tab.5.9.

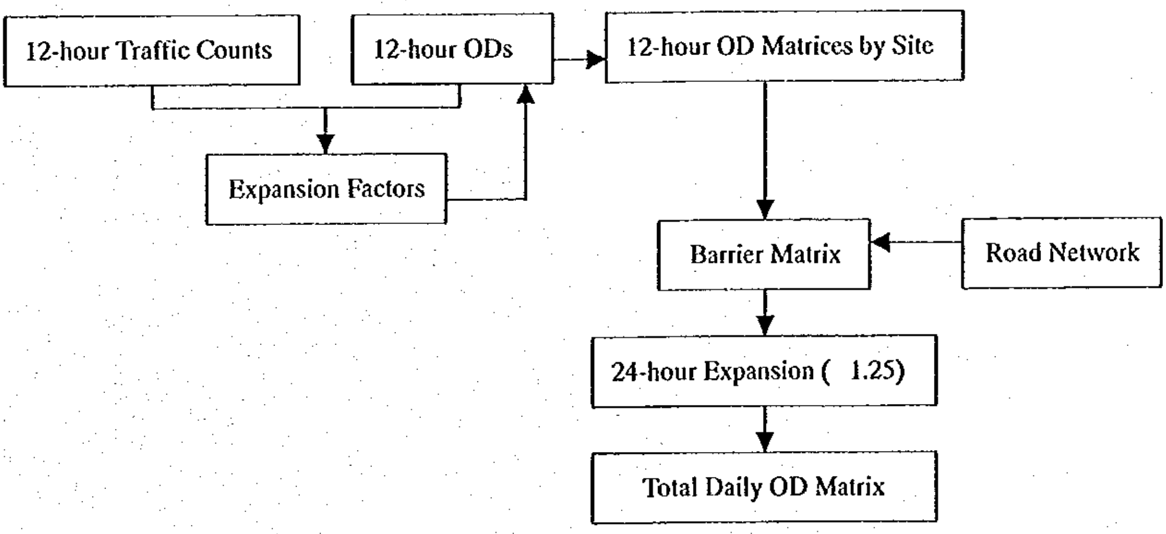


Fig. 5.10 Process for Building Daily OD Matrix

Vehicle OD Matrix for 1999

Vehicle Type : All

Trip Type : All

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
1 Negombo	0	228	244	252	138	1991	358	143	75	68	27	21	0	4	1	13	11	33	140	100	214	88	51	144	491	116	193	85	220	139	101	5689
2 Katana	479	0	215	416	137	1971	556	143	51	50	16	5	0	1	3	3	6	27	101	94	225	75	70	66	334	27	10	9	62	36	87	5274
3 Ja-Ela	310	196	0	806	185	2417	558	173	58	54	17	9	0	2	3	6	7	30	121	129	240	108	76	127	647	41	29	21	117	82	97	6666
4 Wattala	385	326	566	0	761	7202	1552	383	130	111	33	15	0	3	6	11	14	71	261	266	555	344	266	321	620	35	23	23	112	118	221	14732
5 Kelaniya	281	200	305	851	0	6184	1379	316	111	93	30	12	0	3	4	11	13	65	229	240	552	346	276	300	583	30	16	23	102	111	204	12868
6 Colombo	3098	1901	2539	9679	4100	0	26944	5106	1781	1448	392	235	1	33	59	118	199	678	4343	2946	7755	3685	1095	2009	4142	282	242	241	1104	1088	1856	89101
7 Nugegoda	823	587	666	1793	841	29658	0	2058	555	495	117	56	0	7	22	24	64	234	1939	1213	2609	975	334	380	1044	55	31	36	228	205	531	47581
8 Moratuwa	243	163	191	544	244	6024	2051	0	697	409	76	46	0	7	10	23	58	142	873	384	673	222	115	131	349	22	20	23	87	91	207	14124
9 Panadura	106	51	61	148	67	1846	538	675	0	938	64	50	0	6	5	17	48	77	263	132	228	59	27	56	121	11	12	13	44	43	76	5781
10 Kalutara	87	40	53	104	70	1243	371	357	881	0	55	41	0	5	4	19	87	97	255	120	186	57	33	44	100	10	10	12	38	39	79	4498
11 Beruwela	41	18	22	38	23	492	141	88	70	65	0	49	0	5	2	8	7	18	59	37	69	17	10	18	40	4	4	5	16	15	28	1409
12 Matugama	29	7	12	13	12	267	65	49	50	44	47	0	1	27	2	16	7	25	47	32	49	10	5	13	28	3	4	8	16	16	22	929
13 Walallawita	1	0	0	0	0	6	2	1	0	1	1	1	0	0	0	0	0	0	1	1	1	0	0	0	1	0	0	0	0	0	1	18
14 Agalawatte	3	1	1	1	1	28	6	5	5	5	5	27	0	0	0	3	1	3	5	4	5	1	1	2	3	0	1	1	2	2	3	126
15 Dodangoda	2	2	2	4	3	35	12	6	3	3	1	2	0	0	0	0	0	2	3	4	6	2	2	1	3	0	0	0	1	1	3	102
16 Bulathsinhala	14	3	6	7	10	129	30	23	18	20	8	16	0	3	0	0	4	19	27	20	28	7	5	9	16	2	3	4	10	11	16	467
17 Bandaragama	14	5	8	14	9	207	63	61	48	90	6	6	0	1	0	4	0	27	68	22	33	8	3	7	15	2	2	2	6	7	12	752
18 Horana	51	33	40	86	57	820	275	149	90	109	18	25	0	3	3	20	29	0	144	135	163	45	33	30	75	6	5	8	25	27	72	2575
19 Kesbewa	206	93	125	286	149	4382	1691	795	243	272	48	43	0	6	4	25	66	124	0	470	690	152	55	107	240	21	20	22	78	84	151	10647
20 Homagama	193	101	128	272	147	3231	1200	398	131	130	33	28	0	4	5	18	22	113	491	0	1149	146	79	96	250	14	14	18	72	77	185	8746
21 Kaduwella	305	165	221	547	353	6062	1713	527	188	177	47	39	0	6	7	27	28	133	558	1029	0	346	201	223	456	33	29	34	127	170	368	14117
22 Kolonnawa	115	73	106	325	256	4183	1177	201	67	59	16	10	0	2	2	7	8	35	177	154	366	0	99	95	187	15	9	12	46	58	106	7967
23 Biyagama	67	86	119	349	312	1313	427	108	45	38	14	5	0	2	2	7	5	39	68	124	223	164	0	131	220	13	7	11	39	70	128	4136
24 Mahara	163	52	108	289	231	1972	338	115	51	41	14	12	0	2	1	8	7	23	104	95	211	88	89	0	557	39	28	36	191	272	84	5221
25 Gampaha	565	226	546	498	283	3194	674	230	97	86	30	21	0	3	3	14	13	47	190	175	387	141	108	522	0	230	86	78	509	365	158	9478
26 Minuwangoda	139	38	48	40	26	373	77	29	13	12	4	3	0	1	0	2	2	6	26	21	48	14	8	44	263	0	25	19	99	37	18	1433
27 Divulapitiya	190	5	24	17	14	198	23	16	11	10	4	4	0	1	0	3	2	5	19	13	24	10	4	27	81	24	0	42	63	34	15	880
28 Mirigama	88	8	22	21	16	234	35	20	12	12	5	6	0	1	0	4	2	6	21	17	32	11	6	35	79	19	43	0	120	49	22	946
29 Attanagalla	249	65	117	159	107	1144	216	100	46	42	15	16	0	3	1	11	7	27	81	84	142	61	46	222	573	97	68	122	0	291	98	4210
30 Woke	155	35	79	106	87	1137	215	90	46	41	14	17	0	3	1	11	7	25	92	81	186	56	46	283	399	38	34	50	283	0	92	3707
31 Hanwella	138	86	111	243	185	1688	494	174	79	85	28	21	0	4	3	18	13	67	141	185	371	127	117	91	194	18	18	24	83	97	0	4903
	8540	4794	6685	17909	8822	89628	43183	12539	5652	5006	1183	843	5	148	154	449	738	2199	10846	8324	17418	7366	3260	5532	12110	1209	985	980	3900	3634	5042	289083

Tab. 5.9 Vehicle OD Matrix for 1999

2) Traffic Volume Survey

The composition of traffic, as determined by the traffic volume and roadside OD surveys, is shown in Fig. 5.11. As the figure indicates, 58% of the vehicles on the road are private passenger vehicles (i.e., cars and motorcycles), while 22% of vehicular traffic consists of buses (regular buses and minibuses). Freight vehicles and 3-wheelers each accounts for about 10% of total traffic.

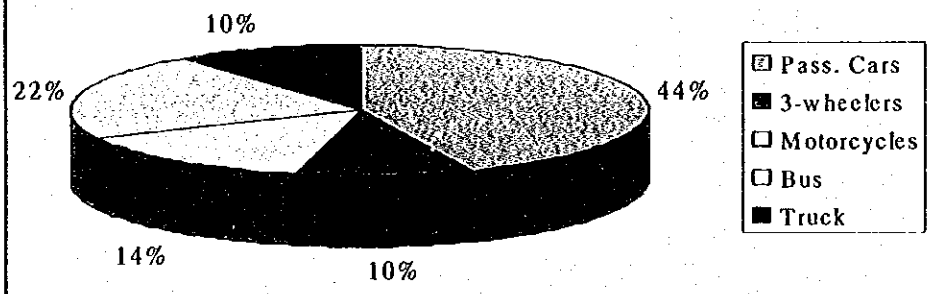


Fig. 5.11 Traffic Composition

Excluding buses and school vans, the average occupancy of the different vehicle classes is as shown in Fig. 5.12. Except for motorcycles, all the different vehicle types had an average occupancy greater than 2, with passenger cars having the largest average value of 2.69 persons per vehicle. Motorcycles had an average occupancy of 1.30.

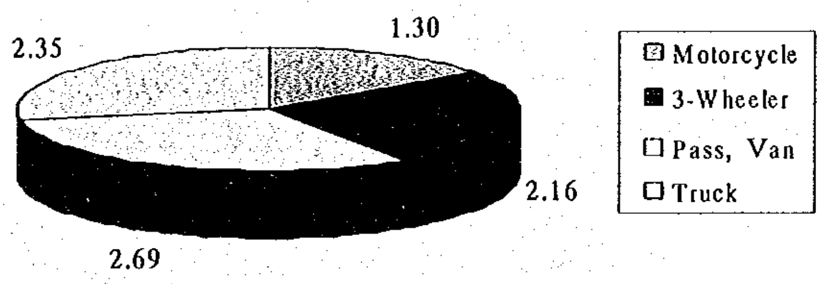


Fig. 5.12 Average Vehicle Occupancy (incl. driver)

As for the actual traffic volumes that were surveyed on site, they are as shown in Fig. 5.13 below.

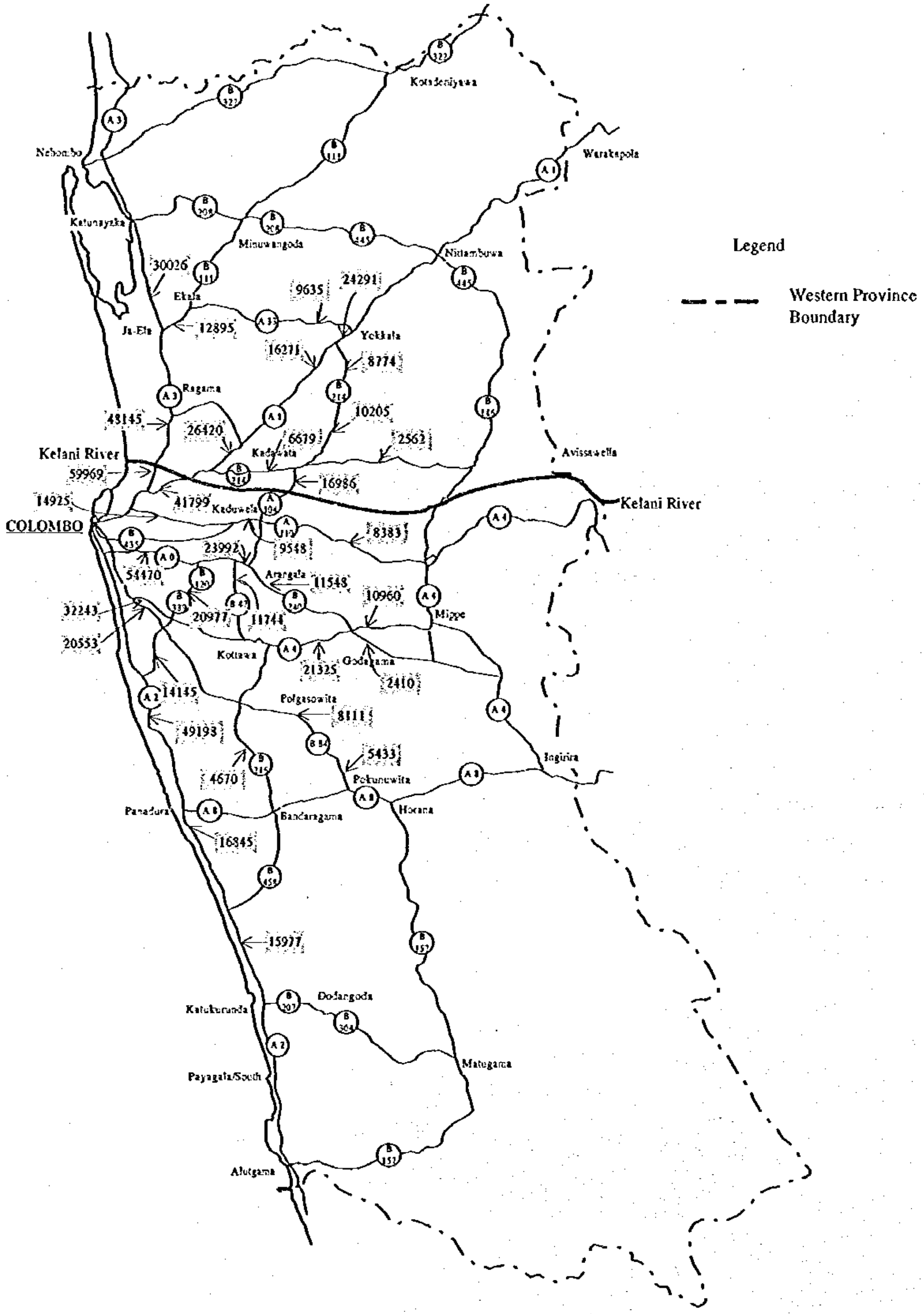


Fig. 5.13 Average Daily Traffic Volume on Major Arterials in Colombo

As Fig. 5.13 indicates, daily traffic flows on arterials near the center of the city are experiencing large volumes of traffic. On A3 at the point nearest Colombo, more than 59,000 vehicles were surveyed coming and going to the city. Of the 34 locations that were surveyed, 5 experienced traffic flows greater than 40,000 vehicles per day and 7 flows greater than 30,000. This indicates that portions of the road network are heavily used and experiencing congestion.

3) Bus Passenger Volume Survey

Three important pieces of information were derived from the bus passenger volume survey: type of bus operation (intra-provincial or inter-provincial), bus capacity, and bus usage conditions. Each of these is shown in the three figures below.

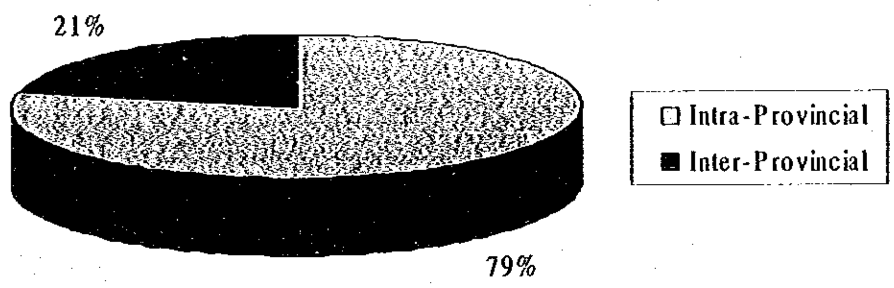


Fig.5.14 Type of Bus Operation

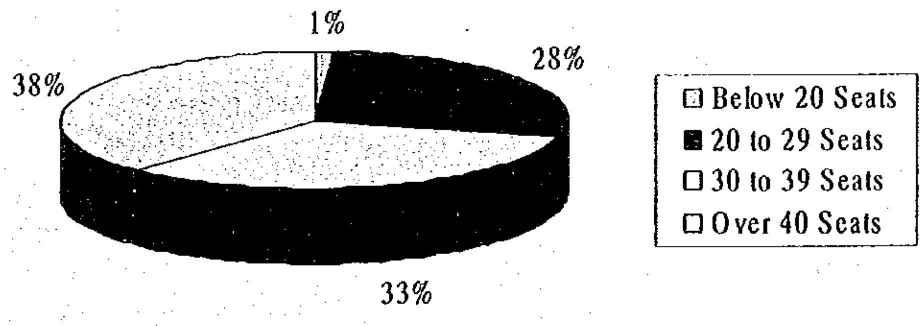


Fig.5.15 Bus Seating Capacity

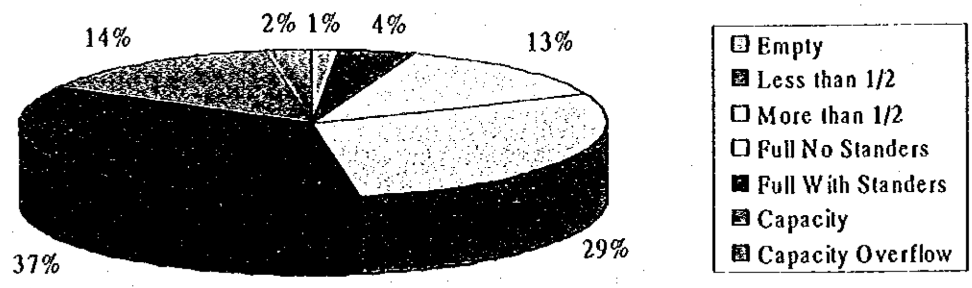


Fig. 5.16 Passenger Loads on Bus

In Fig. 5.14, it can be seen that the vast majority of buses observed (or 79%) operate within the CMR (or Western Province). Of these, only 1% had a seating capacity of less than 20 seats, while 38% had a capacity of more than 40 seats and 33% a capacity between 30 to 39 seats (see Fig. 5.15). The other 28% of the buses observed had a seating capacity between 20 to 29 seats. As Fig 5.16 indicates, buses are used rather extensively, with 53% of those observed being full with no standers or at capacity or greater. If being able to sit down is a criteria for using a bus, then 82% of the buses observed would be unattractive choices for travel.

4) Turning Movement Survey

The purpose of the turning movement survey for this study was solely for grasping the directional flows of traffic at important junctions and not for obtaining data to carry out detailed analyses of intersection design. Refer to Annex 1 for detailed information on the directional flows of intersections.

5) Travel Speed Survey

According to the travel speed survey results, average travel speed on major traffic corridors in Colombo is in the range of 30 to 35 km/h, depending on the time of day and direction. In the direction of Colombo, the morning peak has a minimum travel speed of 28 km/h, which increases to 34 km/h during the off-peak and drops back down to 31 km/h in the evening peak (see Fig.5.17). As for the direction away from Colombo, the morning peak has the highest speed of 35 km/h, indicating that many commuting trips are in the opposite direction. This drops to 30 km/h in the off-peak and rises to 33 km/h in the evening peak (see Fig.5.18).

Fig. 5.17 Average Travel Speed on Major Traffic Corridors to Colombo

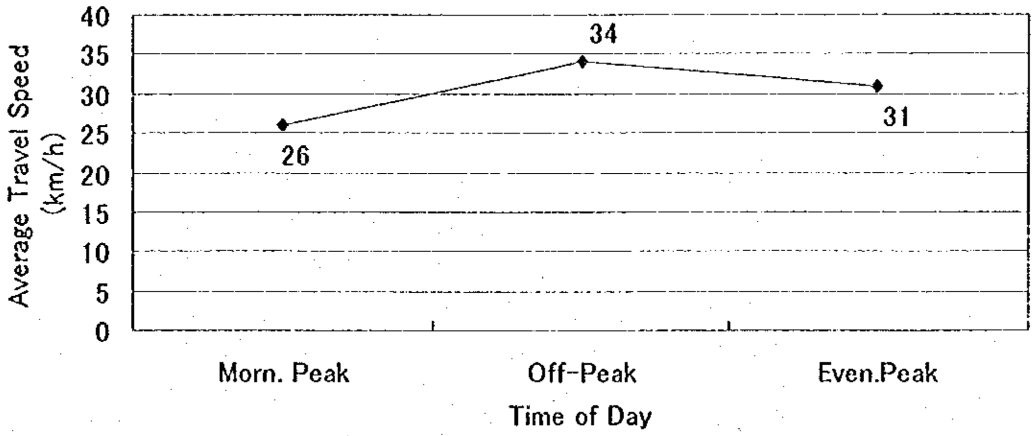
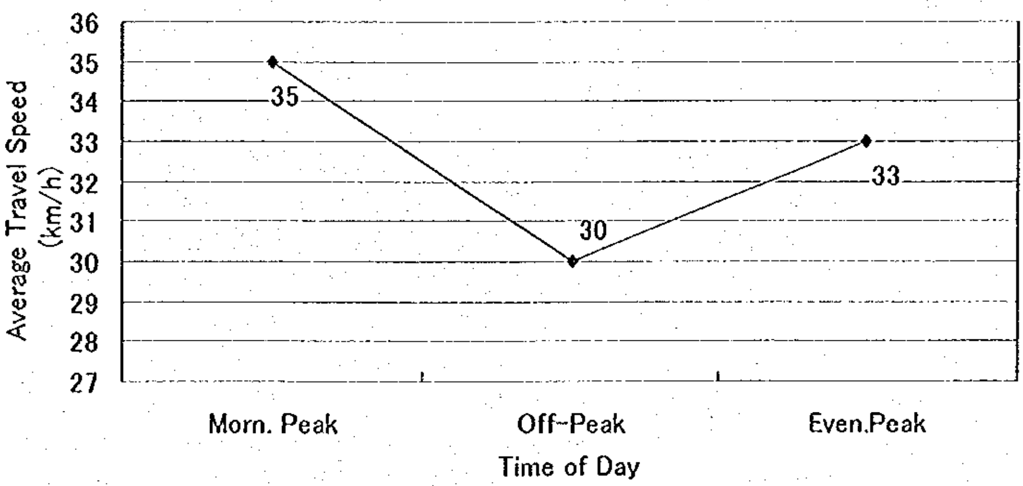


Fig. 5.18 Average Travel Speed on Major Traffic Corridors from Colombo



6) Bus Passenger Interview Survey

The main results of the bus passenger interview survey are shown in figures 5.19, 5.20, 5.21, and 5.22 below. As the first two figures indicate, the mode used most often to access and egress a bus stop is walking at 50.6% and 62.4%, respectively. The mode used next most often is bus, meaning that people are perhaps riding a bus from a minor route to connect with another bus that plies a major route. Other modes, such as car and rail, as connectors to bus transport are insignificant in terms of use, indicating that the concept of park-and-ride is not being practiced. It also seems to indicate that inter-modal transport does not yet exist on any sort of large scale in Colombo. Another important result of the survey was that only 6.2% of the bus users surveyed owned a car, indicating that almost all of the people who ride buses are captive users. That is, they use the bus because they have no choice (see Fig. 5.21). For those who own a car and use a bus, they do so mainly because it is cheaper (56.6%). Only 17.7% said they use a bus because it is more convenient, while another 14.6% said they use a bus because it is faster.

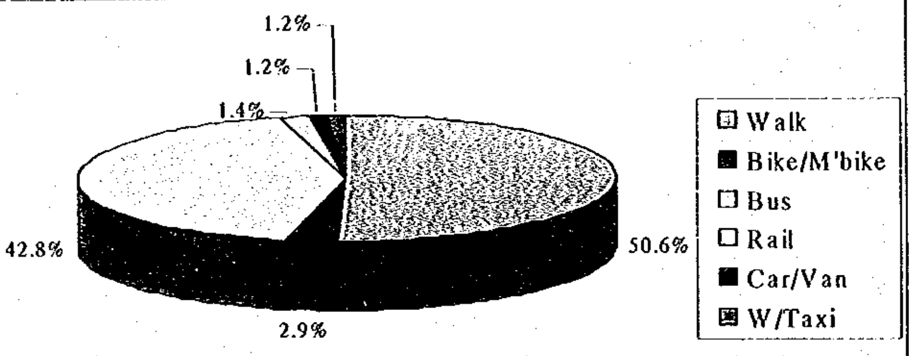


Fig. 5.19 Access Mode to Bus Stops

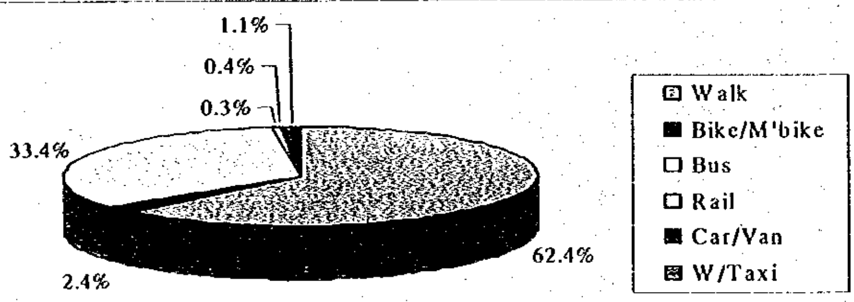


Fig. 5.20 Egress Mode from Bus Stops

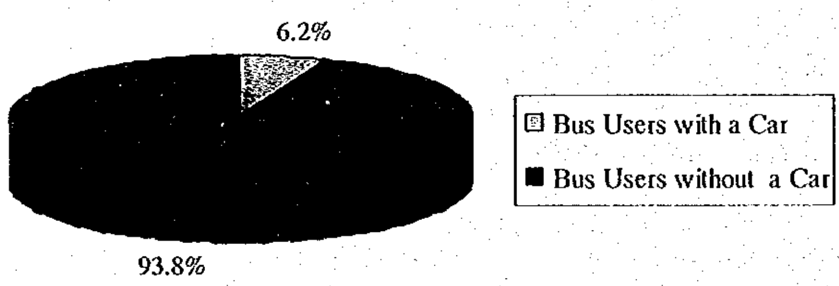


Fig. 5.21 Car Ownership for Bus Users

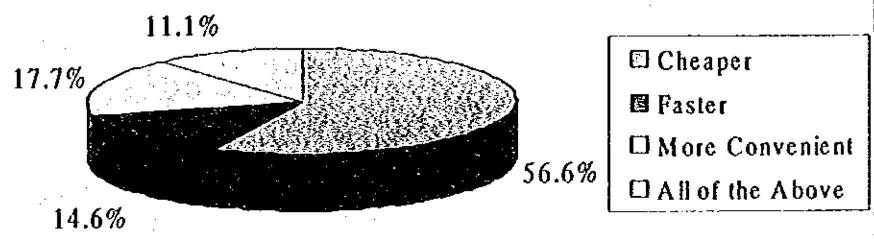


Fig. 5.22 Reasons for Car Owners Using Bus

5.4 Building of Traffic Demand Model

5.4.1 Forecasting Methodology

The traffic demand model employed the traditional 4-step estimation method contained in the JICA STRADA (System for Traffic Demand Analysis) package, which consists of the steps of trip generation/attraction, trip distribution, modal split, and traffic assignment, to calculate the traffic demand for the CMR and OCH. The forecast years for this study were 2010 and 2020. An outline of the basic structure for forecasting traffic is shown in Fig. 5.23. Note that this process was applied only to the estimation of trips that occurred within the CMR. For trips that begin or end outside of the CMR, calculations were carried out using a simple projection method. As for through trips, since they were insignificant in terms of overall volume they were not taken into consideration (see Fig. 5.9).

5.4.2 Outline of Traffic Model Data and Development

Introduction

The study area consisted of the Western Province (or CMR) and was divided into 31 zones as shown in Fig.5.24. The traffic demand model for this area incorporated only the arterial road network. That is, the railway network was not taken into consideration in this study, based on the assumption that modal shares would remain stable. Below, an outline of each of the steps of the traffic demand model, as well as the development of the model itself, for determining the demand for this network is described.

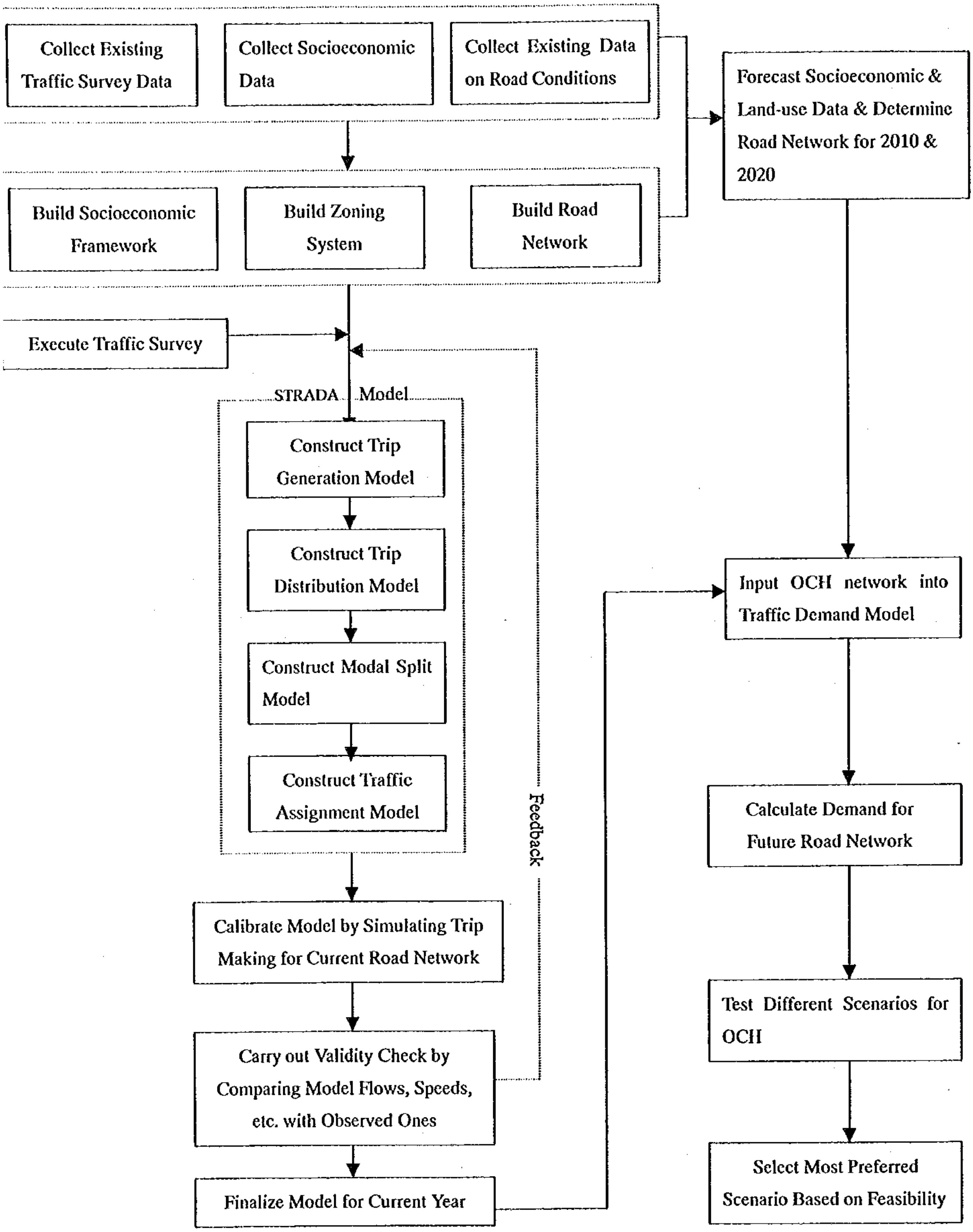


Fig. 5.23 Process for Forecasting Future Traffic Demand

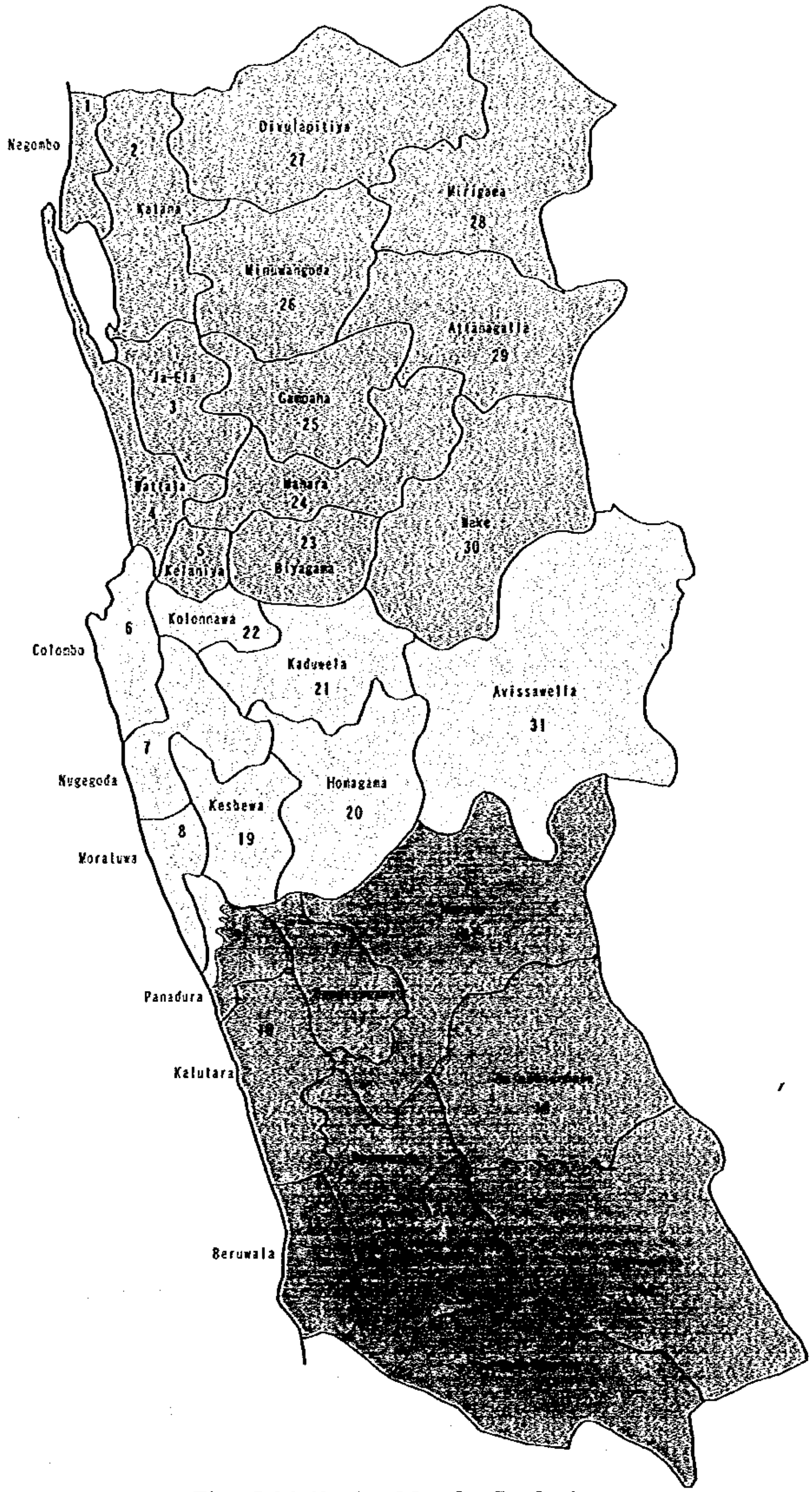


Fig. 5.24 Zoning Map for Study Area

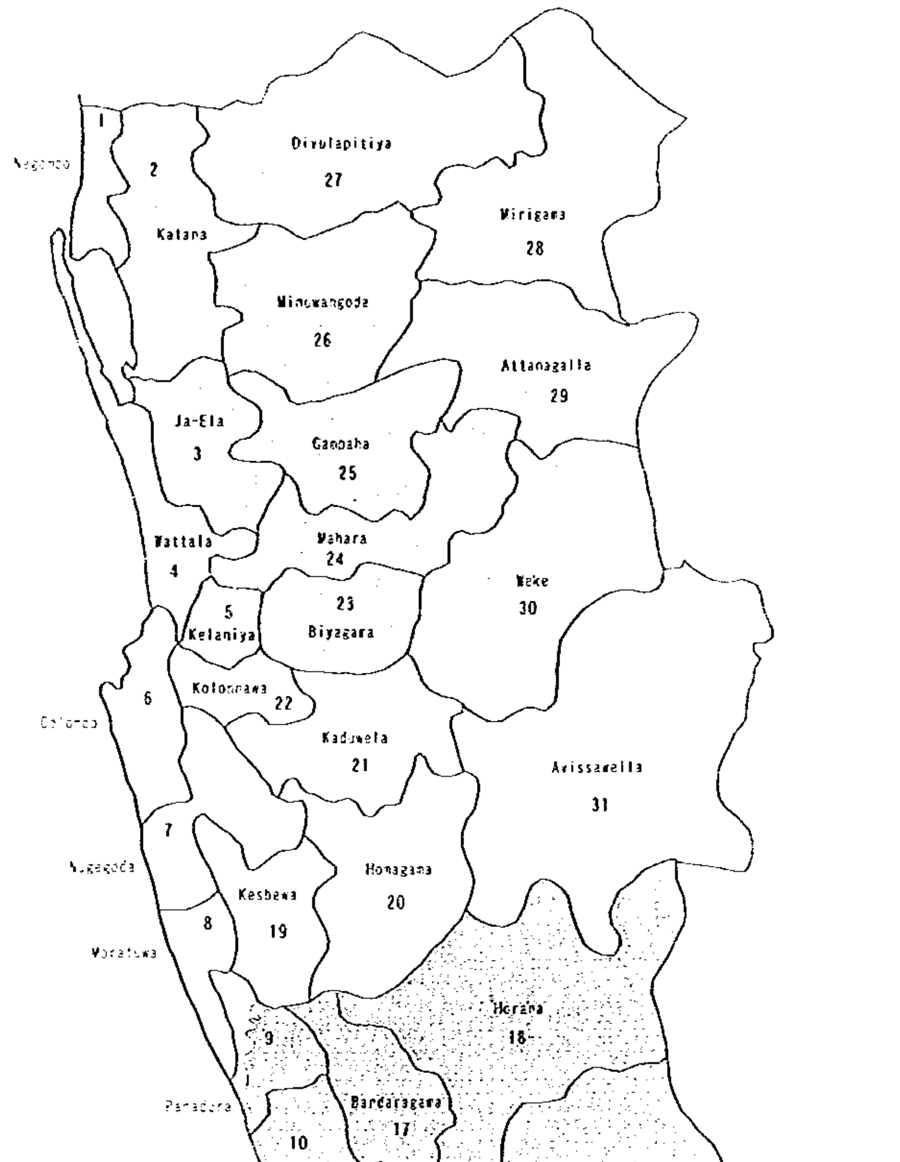


Fig. 5.24 Zoning Map for Study Area

Trip Generation/Attraction

In order to model trip generation/attraction, it is necessary to use trip control totals to ensure that realistic estimates of future traffic demand are obtained. Below, the process for estimating the trip control total and trip generation/attraction values is described.

1) Trip Control Totals

Trip control totals for the CMR were established using the relationship of 'vehicles per capita' and 'vehicles generated' per zone. Based on the traffic survey and socioeconomic data gathered in Colombo, it was assumed that the number of trips per vehicle will decrease as the number of vehicles increases as a result of less intense usage. This resulted in the derivation of the control totals shown in Tab. 5.10. As this table indicates, annual growth in vehicular trips will be about 7.37% until the year 2005 and then drop to 4.34% and 3.32% for the periods of 2005 to 2010 and 2010 to 2020, respectively.

Tab. 5.10 Total Future Daily Trips for the CMR

Year	Daily Trips (Control Totals)
1999	289,100
2005	443,000
2010	548,000
2020	759,000

2) Zonal Trip Generation/Attraction

In order to model vehicle trip generation and attraction, the CMR was divided into 31 zones as shown in Fig. 5.24. This division was based on administrative boundaries. Then, the correlation between various socioeconomic factors and vehicle trip generation/attraction by vehicle type and trip purpose were checked and models constructed. The socioeconomic factors that were considered for trip generation/attraction modeling consisted of employment, population, vehicle ownership, and income. Calculations of socioeconomic factors are described in Chapter 4. The vehicle types considered were cars, 3-wheelers, motorcycles, buses, and trucks. As for trip types, these consisted of home-based work trips, home-based other trips, and non-home-based trips. The calibrated models provided daily (24-hour) trip generation/attraction figures for a typical weekday.

As for trips with a trip end outside of the CMR, it was assumed that the share of these trips would remain the same in relation to total trip making in the CMR and that they would grow in proportion to increases in the number of total CMR trips.

Trip Distribution

Trip distribution simulates the travel patterns of urban travel by applying the concept of ease of travel. Ease of, or deterrence to, travel is usually defined either in terms of cost, time, or distance. In congested urban areas, time or cost is usually used, since distance is not an accurate representation of actual travel. On the other hand, in this study, zonal distance was applied, based on the fact that Colombo has relatively high average travel speeds.

The inputs for trip distribution are the trip ends determined from the roadside OD survey and the actual travel distance between zones. The key outputs are the observed distribution lengths by vehicle type and trip purpose, which are used to calibrate the distribution model together with screen line data.

Trip distribution models were constructed for the 11 types of trips described above (i.e., bus trips, truck trips, and home-based work, home-based other, and non-home-based trips for passenger cars, motorcycles, and 3-wheelers).

Modal Split

The purpose of a modal split model is to simulate the selection process that travelers go through in choosing a mode of transport by which to travel. In this study, it was decided that a modal split model would not be constructed for the following reasons:

1) More than 93% of bus riders are captive users (i.e., they do not possess a car) and are unable to switch to private transport (see Fig. 5.21). In addition, the current low levels of service on buses discourage private vehicle owners from using a bus. That is, there is no realistic choice between private transport and buses. Travelers faced with the choice of either traveling by car/motorcycle or bus will almost always choose the former.
2) Trips by rail, according to recent estimates, account for only about 5% of the total person trips made in the CMR.

Given the above, it was decided not to construct a modal split model. As a result of this decision, modal split follows automatically from the trip generation and attraction stage.

Traffic Assignment

Traffic assignment is the last stage of the traffic demand model and produces outputs (such as vehicle-km, vehicle-hours, travel speed, and congestion rates) that are used to assist in the evaluation of the feasibility of the OCH. In this study, the incremental traffic assignment model was applied because of its ease in checking route and link assignments. In this model, the principle of equal travel times is used. That is, traffic will switch to another route with shorter travel times and this process continues until there are no alternatives. Here, the calculation of travel time is important. To calculate travel time, the following information for the different types of road links is required: capacity, design speed, and speed-flow (QV) functions.

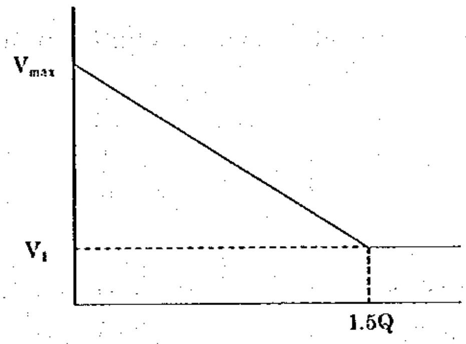
Three parameters that greatly affect the design speed and capacity of a road are geometry, terrain, and land use. Information on road capacity and design speed by road class (which is an expression of highway geometry), terrain, and land use was obtained from the RDA Design Standard. This information, along with design information from Japan used as a reference, was the major factor for setting the maximum daily design capacity for the existing links of the road network (see Tab.5.11). Capacity was then adjusted as necessary for narrowness using an adjustment factor from the American Highway Capacity Manual. As for design speed, it was determined instead that free flow speed would give a more accurate representation of travel on the network from a modeling point of view. Free flow speed was derived by referring to the CUTS survey and to this study's traffic survey. As for the CKE and New Kandy expressways and the OCH and Southern Highway, since Sri Lanka has no experience with this grade of road, Japanese standards were referred to in setting capacity and lane width.

Tab. 5.11 Daily Design Capacity and Free Flow Speeds for Road Network Links

Type of Road	Type of Terrain*	Land Use	Maximum Daily Design Capacity	Lane Width	Free Flow Speed (km/h)
2 Lane A Class	Plain	Urban	25,000	3.10	40
		Suburban/Rural			45
4 Lane A Class	Plain	Urban	50,000	3.70	45
		Suburban/Rural			50
2 Lane B Class	Plain	Urban	20,000	3.10	35
		Suburban/Rural			40
4 Lane B Class	Plain	Urban	40,000	3.70	40
		Suburban/Rural			45
Expressway (CKE, New Kandy Rd.)	Plain	Suburban	72,000	3.50	90
OCH 4 lanes	Plain	Suburban	52,400	3.50	60
OCH 6 lanes			72,000		60
Southern Hwy & Ratnapura Hwy. In 2020	Plain	Suburban	52,400	3.50	60

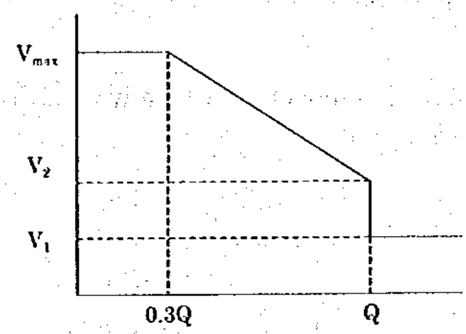
*Since the CMR is mostly flat, only the terrain type plain was considered

As for selecting appropriate QV functions for the above road types, it was decided that those shown in figures 5.25, 5.26, and 5.27 would be used for existing roads, the OCH, and the CKE/New Kandy expressways, respectively. The logic behind this selection is basically that higher grade roads are able to sustain higher speeds at larger volumes. As for the difference between the expressways and the OCH and Southern Highway, since the former is a full-controlled facility, it is possible to close entrances to traffic when levels of service decrease to unacceptable levels.



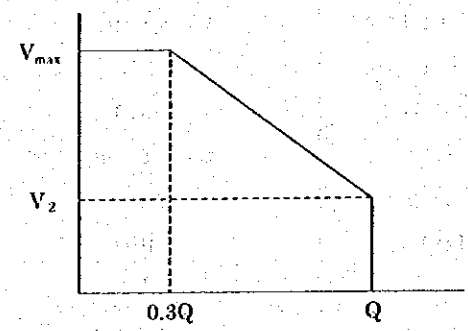
$V_1=0.1*V_{max}$

Fig. 5.25 QV for Existing Roads



$V_1=0.1*V_{max}$ $V_2=0.3*V_{max}$

Fig. 5.26 QV for OCH and Southern Highway



$V_2=0.3*V_{max}$

Fig. 5.27 QV for CKE and New Kandy Expressway

Finally, the mix of traffic is one other item that has to be taken into account in traffic assignment. This is usually handled by converting traffic into passenger car units (PCUs). It was decided to use the PCU standard established by the University of Moratuwa, which is based on Sri Lankan data, in order to sufficiently take into account local conditions. It should be mentioned that a weighted average for buses and trucks was used in the assignment model because of the different types that exist. An extract from the standard is shown in Tab.5.12 for those vehicles seen most commonly in Colombo.

Tab. 5.12 PCU Values by Vehicle Type (excluding hilly terrain)

Type of Vehicle	PCU
Passenger Car	1.00
3-Wheeler	0.75
Motorcycle	0.50
Minibus , Bus (two door)	1.60, 2.40
Light Truck, Medium Truck	1.50, 2.00

Note : Extract from Univ. of Moratuwa standard

5.4.3 Trip Generation/Attraction Model

The results of the trip generation/attraction modeling, which was carried out using regression analysis, are shown in Tab.5.13 and Tab. 5.14.

Tab. 5.13 Vehicle Trip Generation Models

Trip Type	Variable	R^2
1. Car Home-Based Work Trip	Cars/capita	0.82
Car Home-Based Other Trip	Ditto	0.87
Car Non-Home-Based Trip	Ditto	0.85
2. Three-Wheeler Home-Based Work Trip	Cars/capita	0.79
Three-Wheeler Home-Based Other Trip	Ditto	0.88
Three-Wheeler Non-Home-Based Trip	Ditto	0.86
3. Motorcycle Home-Based Work Trip	Cars/capita	0.89
Motorcycle Home-Based Other Trip	Ditto	0.90
Motorcycle Non-Home-Based Trip	Ditto	0.86
4. Bus Trip	Population	0.70
5. Truck Trip	Cars/capita	0.87

Tab. 5.14 Vehicle Trip Attraction Models

Trip Type	Variable	R^2
1. Car Home-Based Work Trip	No. of Employed	0.55
Car Home-Based Other Trip	Population	0.68
Car Non-Home-Based Trip	Population	0.58
2. Three-Wheeler Home-Based Work Trip	No. of Employed	0.55
Three-Wheeler Home-Based Other Trip	Population	0.51
Three-Wheeler Non-Home-Based Trip	Population	0.64
3. Motorcycle Home-Based Work Trip	No. of Employed	0.53
Motorcycle Home-Based Other Trip	Population	0.41
Motorcycle Non-Home-Based Trip	Population	0.65
4. Bus Trips	Population	0.64
5. Truck Trips	Population	0.70

As Tab. 5.13 indicates, the vehicle trip generation models sufficiently explain trip making with an average R^2 (i.e., coefficient of determination) of 0.84. As for the vehicle attraction models, all of them have a lower R^2 when compared to the trip generation models, having an average R^2 of 0.58. This is the case actually in many transportation studies, as trip attraction is usually more difficult to model. Finally, although different socioeconomic factors were checked, it was discovered that cars/capita (which is a proxy for income), no. of employed, and population produced the most valid models in terms of logic and statistical soundness.

5.4.4 Trip Distribution Model

The type of trip distribution model chosen for this study is the widely applied gravity model (Voorhees type) and is as follows:

$$t_{ij} = T_i \frac{U_j f(d_{ij})}{\sum_{k=1}^{n} U_k f(d_{ik})}$$

Where,

T_i = vehicle trips generated

U_j = vehicle trips attracted

d_{ij} = distance between zones

$f(d_{ij})$ = function expressing the travel impedance between zones in terms of distance

$f(d_{ij}) = d_{ij}^{-b}$

Vehicle trip distribution models were constructed using trip and vehicle type data. The desired line chart for all trip types is shown in Fig.5.28. As this figure indicates, the largest number of trips that is made is between Nugegoda and Colombo, Kelaniya and Colombo, Wattala and Colombo, and Kaduwella and Colombo. As for orbital types of trips, they are almost nonexistent and the vast majority of trips are radial in nature, with Colombo being the center of activity.

As Tab.5.15 indicates below, the trip distribution models are capable of simulating the actual distribution of trips quite well. That is, the R^2 was an average of 0.89 and, except for two of the models, all of them had a R^2 greater than 0.80. This means that on average the models were capable of explaining more than 80% of the variation in trip making The models were calibrated taking into consideration the following three factors:

(1) observed average trip length,
(2) the number of daily screen line trips (see Fig. 5.29), and
(3) the daily number of cordon line trips at the Western Provincial Boundary.

The data for these factors were obtained in the traffic surveys previously mentioned, as well as from data supplied by the RDA. As for the screen line and cordon line, the Kelani River was used as a screen line and the boundary of the Western Province as a cordon line. The calibrated trip distribution models were then used for deriving the future OD matrices for the years 2010 and 2020 (see Tab. 5.16 and 5.17 for the all purpose all vehicle type OD).

Tab. 5.15 Vehicle Trip Distribution Model Results

Trip Type		Estimated Parameter	Correlation Coefficient
Passenger car	Home-Based Work Trip	-0.8	0.97
	Home-Based Other Trip	-0.6	0.94
	Non-Home-Based Trip	-0.8	0.97
3-Wheelers	Home-Based Work Trip	-0.9	0.76
	Home-Based Other Trip	-1.0	0.95
	Non-Home-Based Trip	-1.1	0.96
Motorcycle	Home-Based Work Trip	-0.7	0.92
	Home-Based Other Trip	-1.1	0.90
	Non-Home-Based Trip	-0.6	0.95
Truck		-1.4	0.80
Bus		-0.6	0.73

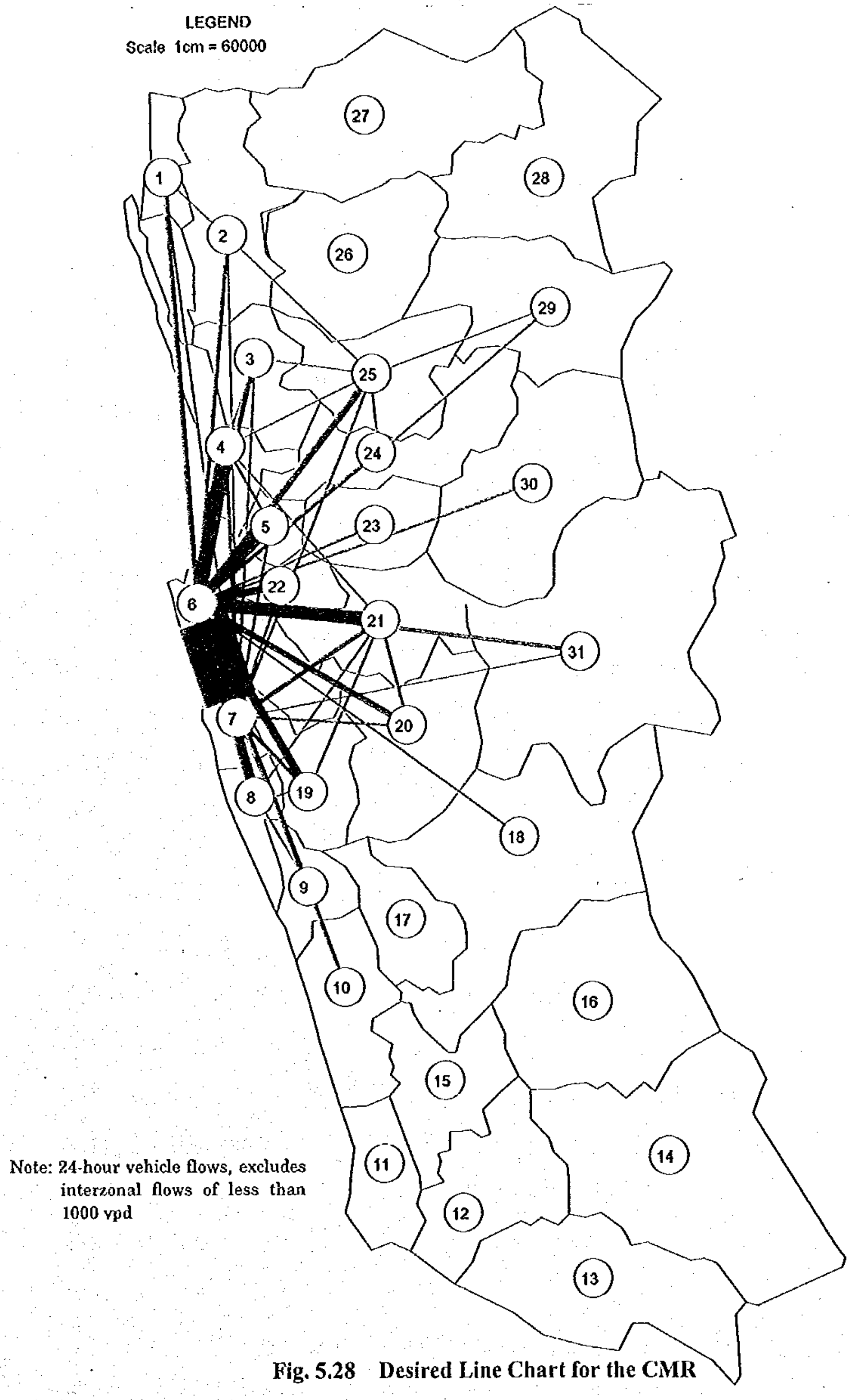


Fig. 5.28 Desired Line Chart for the CMR

Vehicle OD Matrix for 2010

Vehicle Type : All

Trip Type : All

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
1 Negombo	0	1778	666	765	341	4101	1179	431	168	171	91	94	21	45	31	48	102	127	357	292	579	266	199	289	1243	382	326	220	419	272	299	15304
2 Katana	2208	0	487	723	272	2878	1055	321	109	111	61	54	18	36	27	29	76	95	237	208	434	202	174	172	819	309	102	120	204	128	212	11880
3 Ja-Ela	926	572	0	1117	335	3343	1093	329	109	112	59	54	16	34	24	29	75	94	248	225	464	234	192	210	1256	203	82	98	204	158	213	12107
4 Wattala	725	494	629	0	723	5283	1562	411	131	131	68	60	19	39	28	34	92	117	309	289	629	400	298	325	665	135	62	81	150	152	265	14307
5 Kelaniya	486	301	328	965	0	4847	1371	347	114	114	58	52	15	32	23	30	81	104	271	267	604	392	299	330	602	111	44	68	137	144	231	12769
6 Colombo	5441	2994	3010	8029	4526	0	27378	5912	1783	1610	717	665	175	376	303	359	1078	1168	4744	3210	7140	5269	1838	2164	4945	985	476	690	1359	1354	2465	102166
7 Nugegoda	1635	1048	937	2113	1193	26105	0	2743	714	662	279	251	72	156	127	140	499	519	2587	1559	2798	1976	694	586	1525	327	144	225	391	389	890	53289
8 Moratuwa	724	436	377	791	423	7357	3634	0	1044	714	214	192	46	104	91	96	441	370	1512	699	1058	484	270	241	655	142	71	109	183	182	432	23093
9 Panadura	206	105	92	165	96	1663	688	843	0	997	105	100	17	41	38	37	185	138	308	184	308	104	65	71	181	39	22	33	59	61	127	7078
10 Kalutara	241	127	112	203	123	1727	748	640	1060	0	113	107	19	46	42	49	379	210	410	213	357	117	84	80	215	46	24	37	66	68	160	7826
11 Beruwela	249	154	124	238	124	1592	694	375	205	204	0	191	41	83	62	43	112	120	243	183	325	111	88	76	219	50	26	41	64	61	158	6258
12 Matugama	243	141	116	218	116	1459	641	335	186	186	195	0	56	260	257	75	102	169	234	199	307	104	82	72	211	47	25	41	67	64	172	6377
13 Walallawita	246	169	129	257	126	1524	697	309	134	137	136	170	0	144	73	51	85	122	203	181	304	109	91	70	217	51	26	43	61	55	175	6096
14 Agalawatte	235	157	123	242	121	1477	679	315	147	149	130	365	68	0	107	74	90	136	209	185	302	106	87	69	209	48	24	42	62	56	175	6191
15 Dodangoda	206	140	109	214	109	1461	669	339	169	169	118	422	41	126	0	46	89	124	191	165	270	100	79	60	184	43	21	35	51	47	150	5948
16 Bulathsinhala	246	159	128	257	132	1606	748	335	138	162	83	127	31	94	49	0	119	211	257	226	364	117	100	76	221	51	26	46	73	70	214	6464
17 Bandaragama	175	103	89	178	99	1373	681	453	232	424	66	61	13	30	24	37	0	226	389	178	304	95	67	58	161	35	17	27	46	46	122	5807
18 Horana	230	139	119	235	134	1602	766	401	187	251	75	109	21	51	38	75	240	0	358	314	389	124	93	79	215	47	24	40	66	67	193	6681
19 Kesbewa	667	385	340	692	389	6768	3988	1763	434	522	168	162	38	86	64	94	442	389	0	977	1295	475	250	228	598	128	64	98	171	178	427	22283
20 Homagama	656	397	351	744	425	5446	2901	954	313	317	140	150	37	83	62	87	235	381	1085	0	2269	427	290	240	635	132	61	98	170	181	505	19773
21 Kaduwella	1068	651	596	1376	824	9765	4125	1185	445	449	201	186	49	108	79	112	330	400	1201	1935	0	864	576	445	1080	223	101	156	284	333	864	30014
22 Kolonnawa	554	359	346	919	587	8163	3478	607	180	169	81	72	21	45	34	41	121	147	508	398	968	0	304	258	572	120	52	80	144	154	329	19811
23 Biyagama	381	265	254	633	416	2654	1082	291	104	105	54	47	15	31	23	29	74	96	228	239	559	275	0	322	484	95	39	65	125	215	258	9458
24 Mahara	518	307	298	746	477	3374	1075	318	115	116	59	56	15	33	23	31	77	96	255	238	521	261	358	0	1065	151	61	102	289	371	235	11641
25 Gampaha	1302	664	957	742	438	3957	1212	409	156	160	83	83	20	42	29	44	100	125	333	302	621	290	262	700	0	597	144	185	726	536	298	15518
26 Minuwangoda	923	794	428	517	254	2404	903	278	98	101	55	49	15	32	23	27	68	85	207	190	400	176	166	207	1309	0	109	133	328	152	194	10625
27 Divulapitiya	1191	598	372	545	231	2512	949	310	110	114	64	57	19	38	28	32	76	95	225	203	409	173	160	168	670	226	0	206	231	138	229	10381
28 Mirigama	777	510	332	506	245	2604	1010	335	121	125	70	67	22	45	32	39	83	111	243	223	441	185	183	203	674	205	154	0	384	190	292	10408
29 Attanagalla	842	513	395	549	297	2904	1021	340	125	129	69	70	19	41	29	42	83	112	258	237	475	212	217	372	1313	330	125	277	0	437	319	12152
30 Weke	627	381	350	602	331	3167	1159	369	140	143	75	75	20	45	31	46	94	125	299	277	610	247	388	501	1064	175	82	151	469	0	366	12406
31 Hanwella	831	529	444	943	504	5493	2253	761	287	310	155	162	46	102	72	104	210	307	614	654	1352	461	415	305	794	176	90	165	289	301	0	19129
-	24759	15372	13038	26222	14410	128609	69440	22764	9258	9064	3844	4311	1026	2429	1874	1980	5837	6519	18522	14653	26858	14355	8370	8980	24003	5607	2623	3713	7274	6559	10967	513240

Tab. 5.16 Vehicle OD Matrix for 2010

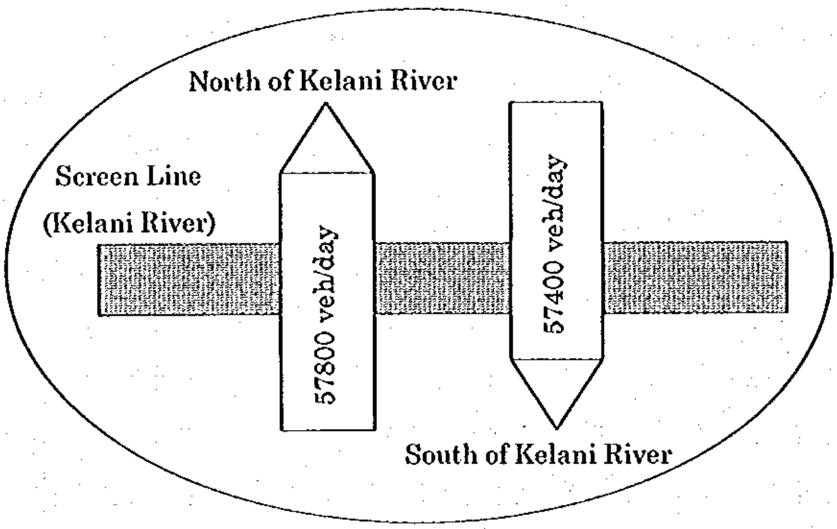
Vehicle OD Matrix for 2020

Vehicle Type : All

Trip Type : All

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
1 Negombo	0	4244	1045	1019	541	5195	1802	696	258	231	162	148	41	86	68	101	219	239	549	426	816	451	376	468	2165	700	553	356	731	387	573	24645
2 Katana	5143	0	732	855	396	3393	1429	478	169	147	112	88	34	69	54	64	156	170	356	285	562	325	306	320	1407	623	227	230	411	205	372	19117
3 Ja-Ela	1863	1142	0	1372	487	3926	1546	491	167	145	107	85	32	65	51	63	155	169	367	299	600	377	330	373	1994	389	167	177	358	221	375	17892
4 Wattala	1424	922	878	0	906	5807	2075	579	189	161	115	90	34	70	55	68	178	193	438	356	738	590	463	490	1015	249	123	145	271	211	429	19263
5 Kelaniya	1000	600	477	1214	0	5930	2013	538	175	148	103	82	29	61	49	62	164	176	418	332	735	633	510	510	990	222	96	130	259	210	413	18278
6 Colombo	8457	4630	3455	7622	5379	0	30149	6827	2031	1653	992	803	262	552	489	588	1766	1668	5278	3477	7554	6522	2525	2479	6202	1461	743	1013	1866	1436	3379	121258
7 Nugegoda	3024	1813	1243	2379	1651	27920	0	3725	984	807	456	368	125	265	232	276	958	864	3475	1994	3447	2971	1081	811	2200	558	282	430	659	528	1424	66948
8 Moratuwa	1426	817	532	923	607	8227	4927	0	1436	902	363	287	84	186	181	188	890	645	2091	941	1390	737	437	345	999	256	139	208	318	247	722	31450
9 Panadura	501	275	176	285	188	2398	1282	1423	0	1242	200	160	39	91	96	82	430	287	495	285	480	212	147	121	353	90	50	76	118	91	265	11939
10 Kalutara	527	292	184	296	197	2304	1258	1035	1362	0	205	164	40	94	100	100	793	401	616	317	509	214	161	127	384	96	52	81	125	96	315	12446
11 Beruwela	600	357	215	351	213	2226	1166	663	348	311	0	326	92	181	151	102	248	228	416	304	528	211	184	144	437	117	66	98	143	104	331	10861
12 Matugama	567	326	197	319	196	1996	1069	578	297	270	360	0	116	491	585	159	245	344	384	321	488	193	168	130	409	105	58	93	138	99	350	11051
13 Walallawita	577	363	212	349	204	2003	1082	517	228	207	281	308	0	304	168	125	205	253	339	285	465	196	175	131	412	114	64	99	136	93	343	10236
14 Agalawatte	561	347	205	336	201	1991	1083	540	252	228	270	631	149	0	250	179	220	287	355	298	478	195	173	130	405	111	61	98	137	96	353	10620
15 Dodangoda	514	319	189	311	189	2027	1093	599	303	271	256	818	92	282	0	117	225	271	335	275	434	190	158	117	368	100	54	86	120	83	311	10506
16 Bulathsinhala	582	353	215	359	217	2178	1199	563	231	242	167	221	68	198	114	0	285	434	424	357	608	217	191	144	433	116	65	109	156	114	424	10984
17 Bandaragama	491	283	179	301	195	2280	1371	948	457	741	143	129	35	80	72	103	0	567	772	334	531	219	160	124	366	93	49	77	116	89	303	11606
18 Horana	549	318	202	338	217	2246	1292	712	319	385	138	195	47	112	92	172	590	0	609	518	636	227	190	148	426	109	58	97	143	110	398	11593
19 Kesbewa	1326	760	502	871	588	7749	5638	2560	613	660	292	243	73	160	131	184	898	690	0	1323	1739	757	449	355	985	248	129	202	312	249	740	31428
20 Homagama	1285	758	497	870	563	6308	4072	1406	425	402	249	233	72	158	127	178	472	688	1545	0	3065	679	509	387	1056	262	132	210	322	257	877	28064
21 Kaduwella	2046	1208	817	1515	1037	11239	5741	1738	601	540	355	290	95	205	161	249	621	719	1719	2628	0	1289	971	692	1764	430	209	342	526	457	1486	41689
22 Kolonnawa	1171	725	530	1187	896	9829	5087	936	281	234	149	118	42	89	73	90	267	266	772	573	1301	0	527	379	907	228	113	175	266	228	587	28027
23 Biyagama	905	600	412	871	661	3558	1697	491	171	154	111	88	32	66	52	68	171	196	400	380	872	473	0	564	1207	243	102	167	298	361	493	15867
24 Mahara	1078	701	517	1017	717	3898	1493	465	166	149	109	88	31	64	50	66	161	183	383	347	740	389	634	0	2267	331	124	177	448	431	413	17638
25 Gampaha	2513	1362	1374	925	662	4599	1674	591	218	201	143	126	37	79	62	89	202	229	487	430	870	426	648	1373	0	985	240	282	1105	670	570	23170
26 Minuwangoda	1894	1597	647	642	392	2865	1244	415	148	134	103	82	32	64	49	60	144	161	316	277	556	277	339	386	2128	0	225	244	585	221	360	16588
27 Divulapitiya	2426	1181	557	665	350	2956	1327	468	167	151	121	94	38	76	59	70	161	178	337	290	561	283	298	283	1096	442	0	372	425	200	418	16051
28 Mirigama	1506	952	468	605	362	3096	1524	528	191	177	136	114	44	91	69	90	189	224	397	351	695	334	370	311	1041	374	288	0	631	373	584	16116
29 Attanagalla	1691	1053	593	716	455	3461	1440	506	185	170	128	110	38	80	61	86	176	208	393	345	677	333	420	525	2078	598	232	440	0	550	565	18311
30 Weke	1217	761	515	782	498	3631	1643	546	198	180	133	112	39	83	63	90	190	222	435	386	815	395	676	654	1624	318	151	361	702	0	624	18045
31 Hanwella	1665	979	621	1083	706	6166	2973	1084	398	398	268	251	86	185	141	210	428	536	874	876	1776	696	659	461	1360	340	192	352	526	422	0	26713
	48529	30039	18386	30376	19870	151398	91390	32647	12969	11638	6728	6856	1977	4588	3904	4079	11808	11698	25774	19612	34666	21013	14237	13479	38478	10308	5044	6926	12350	8838	18796	728402

Tab. 5.17 Vehicle OD Matrix for 2020



Observed／Modeled North of Kelani River : 1.023
South of Kelani River : 1.076

Fig. 5.29 Average Daily Traffic Volume at Screen Line (1999)

5.4.5 Modal Split Model

A modal split model was not developed for the reasons previously given in the section on Modal Split in 5.4.2.

5.4.6 Traffic Assignment Model

The validity and calibration of the traffic assignment model was carried out comparing modeled and observed daily traffic flows at sites where traffic volume counts were executed (see Tab. 5.18), except for those sites with traffic flows of less than 10,000 vehicles per day. (Refer to Fig. 5.3 for site locations.)

As Tab. 5.18 indicates, the average deviation between estimated and observed flows is about 15%, which is acceptable from the strategic level of analysis that is being carried out for this study. Except for Site 29, the modeled and observed traffic flows for each site are generally acceptable. However, it should be noted that modeled flows are on average about 15% less than actual flows.

In terms of modeled and observed speed flows, modeled speed flows for all 8 of the major corridors in Colombo fall within the range of actual speeds observed (see Tab.5.19). Observed average daily speed for all of the corridors was 32.7 km/h as compared to the modeled average of 33.6 km/h. Indicating that the traffic assignment model simulated overall traffic speeds satisfactorily.

Tab.5.18 Comparison of Model Estimates with Observed Traffic Volumes

Site	Model Total (Vehicle)	Observed (Vehicle)	Model/Observed
1	52200	60000	0.87
2	37900	41800	0.91
3	9700	14900	0.65
4	39200	54500	0.72
5	28500	32200	0.89
6	20300	20600	0.99
7	34700	49200	0.71
8	25500	30000	0.85
9	21500	24300	0.88
11	16100	17000	0.95
13	7100	11000	0.65
16	12300	16000	0.77
17	14100	12900	1.09
19	46800	48100	0.97
20	31500	26400	1.19
21	16800	16300	1.03
23	9000	10200	0.88
26	19900	24000	0.83
27	9200	11700	0.79
28	13400	11500	1.17
29	10100	21000	0.48
30	5400	14100	0.38
31	16200	21300	0.76
34	17600	16800	1.05
Average			0.852

Tab. 5.19 Comparison of Observed and Modeled Travel Speeds

Route Line	Observed Daily Travel Speed		Modeled Daily Travel Speed
	Range	Average	Average
A1	29.3-39.0	34.4	35.7
A4	18.8-32.9	27.5	32.1
A104, A0	20.3-38.3	30.6	34.0
A3	29.8-46.5	38.3	40.3
A2	27.8-37.2	33.1	36.6
B84	25.4-39.8	30.0	25.5
B214	28.3-38.5	32.6	31.5
A110	31.5-40.3	35.3	32.8

5.5 Future Traffic Demand

By applying the calibrated traffic assignment model above, forecasts for 2010 and 2020 are carried out after inputting the future road network for the target years of 2010 and 2020.

5.5.1 Future Road Network Improvements

To calculate future traffic demand for the OCH, it is imperative to consider future road construction and improvements. These are shown in Fig. 5.30. Except for the New Kandy Expressway, the new Ratnapura Road, and the northward extension from the airport (completion to be 2020), it is assumed that all road improvements and construction schemes will be completed by the year 2010.

1) New Road Construction

The new road construction considered in the model is as follows:

(1) The Northeast Highway to Kandy: This route would improve access to the north (including Kandy) and east of the country and reduce congestion on Route A1 and A3. Its terminus in Colombo would be the northern entrance to the Baseline Road.

(2) The Southeast Highway to Ratnapura: This route would connect the southern part of the Baseline road with Ratnapura and provide more access to areas in the outer suburbs of CMR to the core of the city.

(3) The Katunayake Expressway: This alignment would be a fully-controlled toll road that would connect the City of Colombo with the city's international airport. The intention is to provide reliable, timely service for travelers going to/from the airport.

(4) The Baseline Road Extension: This would extend the Baseline Road from its current southern terminus of Kirillapone straight to Attidiya in the south (or about 5.5 km), which would then extend down to Galle Road via an existing road.

(5) The Katunayake-Padeniya Highway: This would further improve access to the airport and extends north beyond the boundary of the CMR to Padeniya in the North West Province.

Colombo Metropolitan Region

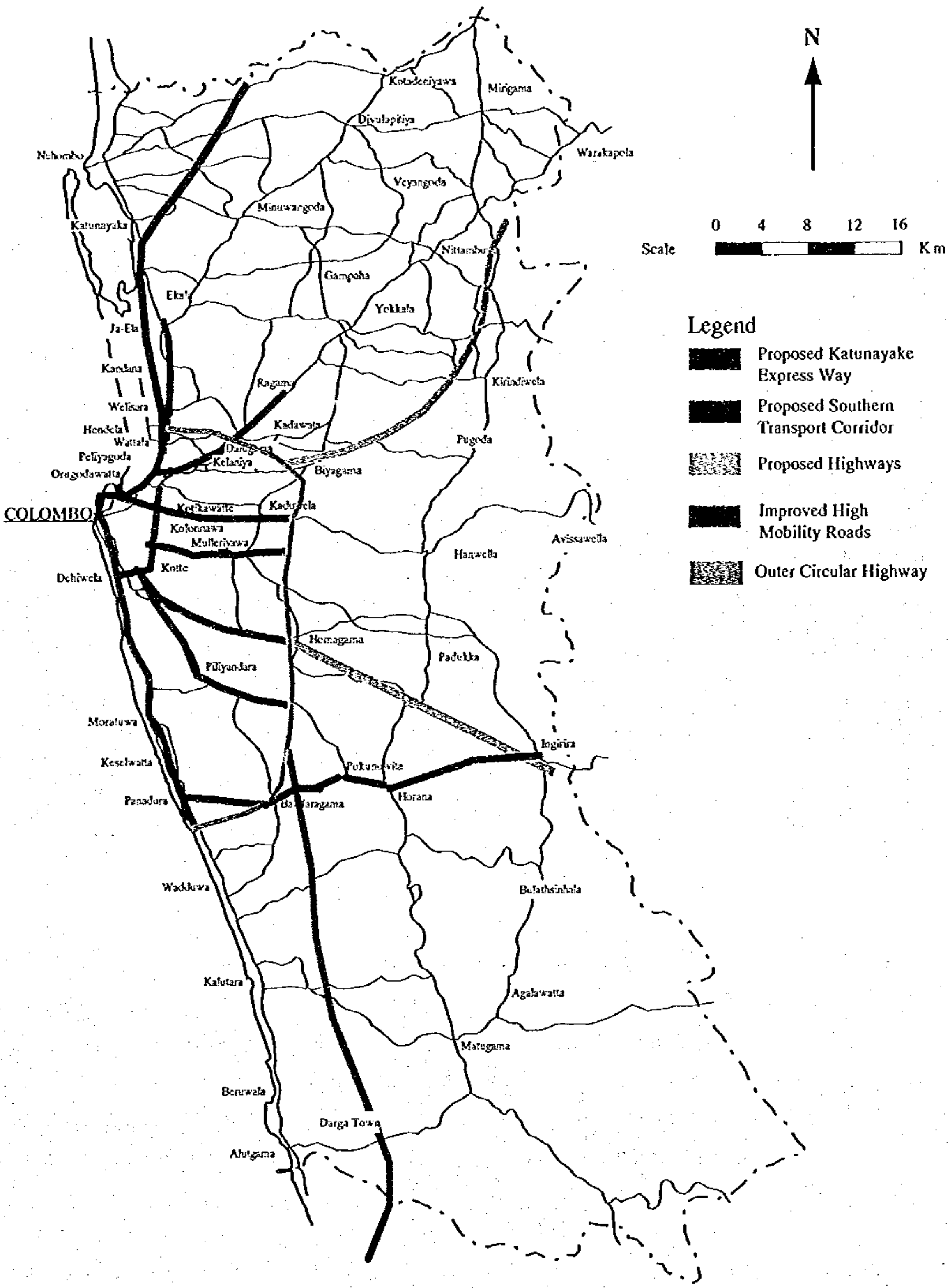


Fig. 5.30 Future Road Improvement & Construction

New Road Improvements

Future road improvements for the CMR focus on improving the capacity of nine existing corridors to improve speeds to around 30-40 km/h. The total length of these corridors is 180 km and they would have as one of their main purposes the distribution of inter-regional traffic to the area of the Colombo Metropolitan Council and its suburbs. These nine corridors and the sections to be improved, as well as their length, are indicated in Tab. 5.18 below.

Tab. 5.20 High Mobility Corridors

Name of Corridor	Location of Sect. for Improvement	Length of Sect. Improvement
Route A1 (Colombo-Kandy Rd)	Up to Kadawatha interchange with North-South Highway.	18 km
Route A2 (Colombo-Galle-Hambantota-Wellawaya Rd)	Up to Panadura	28 km
Route A3 (Peliyagoda-Puttalam Road)	Up to Ja-El interchange with North-South Highway.	20 km
Route A4 (Colombo-Ratnapura-Wellawaya-Batticaloa Rd)	Up to Kottawa interchange with North-South Highway.	22 km
Route B84 (Colombo-Horana Rd)	Up to Polgasowita interchange with North-South Highway.	20 km
Route A110 (Colombo-Hanwella Rd)	Up to Kaduwela interchange with North-South Highway	15 km
Route A0 (Kollupitiya-Sri Jayawardena Pura Rd)	Up to Talangama interchange with North-South Highway.	15 km
Route A8 (Panadura-Nambapana-Ratnapura Rd)	Up to Ingiria	34 km
Baseline Road	Improved to dual 3-lane carriageway.	8 km
Total		180 km

Source: Based on data from Urban Development Authority, *Colombo Metropolitan Structural Plan*, Vol. II. 1998.

5.5.2 Traffic Demand Forecasts for 2010 & 2020

In addition to the future road improvements and construction mentioned in the previous section, 9 different possible alignments for the OCH were examined for possible incorporation into the future road network, which were decided in consultation with the RDA (see Chapter 8). Here, only the traffic demand forecast for the alignment that was selected as the most preferred route is taken up and examined for the future years of 2010 and 2020 in comparison to the case of no OCH being built. A comparison of the present situation with and without the existence of the OCH is also done for the purposes of reference.

In tables 5.21 to 5.23, the traffic indices of vehicle-kilometers, vehicle-hours, average area congestion, and average area speed are used to assess the impact of the OCH on the CMR.

Tab. 5.21 Comparison Traffic Impact with and without the OCH for 1999

	Daily Veh-km For CMR (mil)	Daily Veh-hrs for CMR (mil)	Daily Average VCR	Daily Average Speed
Without OCH	8.99	0.26	0.47	32.7
With OCH	8.92	0.26	0.41	34.7
Ratio of with/without	0.99	1.00	0.87	1.06

Tab. 5.22 Comparison Traffic Impact with and without the OCH for 2010

	Daily Veh-km for CMR (mil)	Daily Veh-hrs for CMR (mil)	Daily Average VCR	Daily Average Speed
Without OCH	19.69	0.71	0.83	27.7
With OCH	19.57	0.65	0.73	30.3
Ratio of with/without	0.99	0.92	0.88	1.09

Tab. 5.23 Comparison Traffic Impact with and without the OCH for 2020

	Daily Veh-km for CMR (mil)	Daily Veh-hrs for CMR (mil)	Daily Average VCR	Daily Average Speed
Without OCH	30.11	1.20	1.06	25.2
With OCH	29.40	1.04	0.92	28.4
Ratio of with/without	0.98	0.87	0.87	1.13

The conclusions that can be drawn from the construction of the OCH based on the above tables are as follows:

1) The impact of the OCH becomes larger as time passes by. In the year 2020, the construction of the OCH would result in daily area speeds being 1.13 times faster as compared to only 1.06 times faster if the OCH was in existence today. In the year 2010, the construction of the OCH would result in average area travel speeds being 1.09 times faster.
2) The reduction in distance traveled on the road network with the introduction of the OCH is slight. In the year 2010 it is a small 1% and would reach 2.4% in the year 2020, indicating an increase in the number of orbital trips. On the other hand, vehicle-hours would be 11% and 13% less in the years 2010 and 2020, respectively, as compared to the case of there being no OCH.
3) The difference in actual area travel speeds with and without the OCH is 2.7 km/h in 2010 and 3.2 km/h in 2020. These are substantial differences in speed for an urban area.

4) Area wide congestion with the OCH would be about 12% less as compared to without.

The above clearly indicates that the OCH would be a feasible proposition from the perspective of the impact that it would have on area-wide traffic. As for the traffic demand on the OCH itself, estimates by this study indicate that the OCH would be a highly traveled facility. For example, in the year 2010, a daily total of about 91,000 vehicles would use the OCH, while in 2020 this total would be about 142,000 vehicles per day. The average traffic flow for a section of road on the OCH would be about 37,000 pcus in 2010 and 45,100 pcus in 2020. Given these traffic volumes, it is suggested that the OCH be constructed initially as a 4-lane facility. The most congested parts of the OCH would be located in the middle of this ring road and the least congested parts at the tail ends. However, as shown in Fig.5.31 for 2010, the northern tail end would have a much higher traffic volume (34,500 pcus) as compared to the southern tail end (19,200 pcus).

In the year 2020, pcus flows indicate that the entire middle portion of the OCH is over capacity. Although a 4-lane OCH facility is sufficient to handle the required traffic flows in the year 2010, improvements to the OCH will be necessary to handle the traffic generated in the year 2020. Except for the southern tail end of the OCH, it is suggested that the OCH be made into a 6-lane facility for the year 2020. Although traffic on the northern tail end and on the section between A8 and the Southern Highway can be handled by a 4-lane structure, it would be better from a network point of view to make these 2 sections into 6-lane structures as well. That is, because the northern tail end would connect the important CKE with the 6-lane portion of the OCH, which intersects the busy Kadawata area, it would be in the long run strategically better for the northern tail end to become a 6-lane facility. In the case of the OCH portion between A8 and the Southern Highway, it is quite short in length (less than 1 km) and it would be rather pointless to only retain this section of the OCH straightaway as a 4-lane structure. As for the southern tail end of the OCH, its traffic demand of 28,200 pcus requires that it remain as a 4-lane structure.

Given the above, it can be said that the OCH is viable and necessary for the Colombo Metro Region.

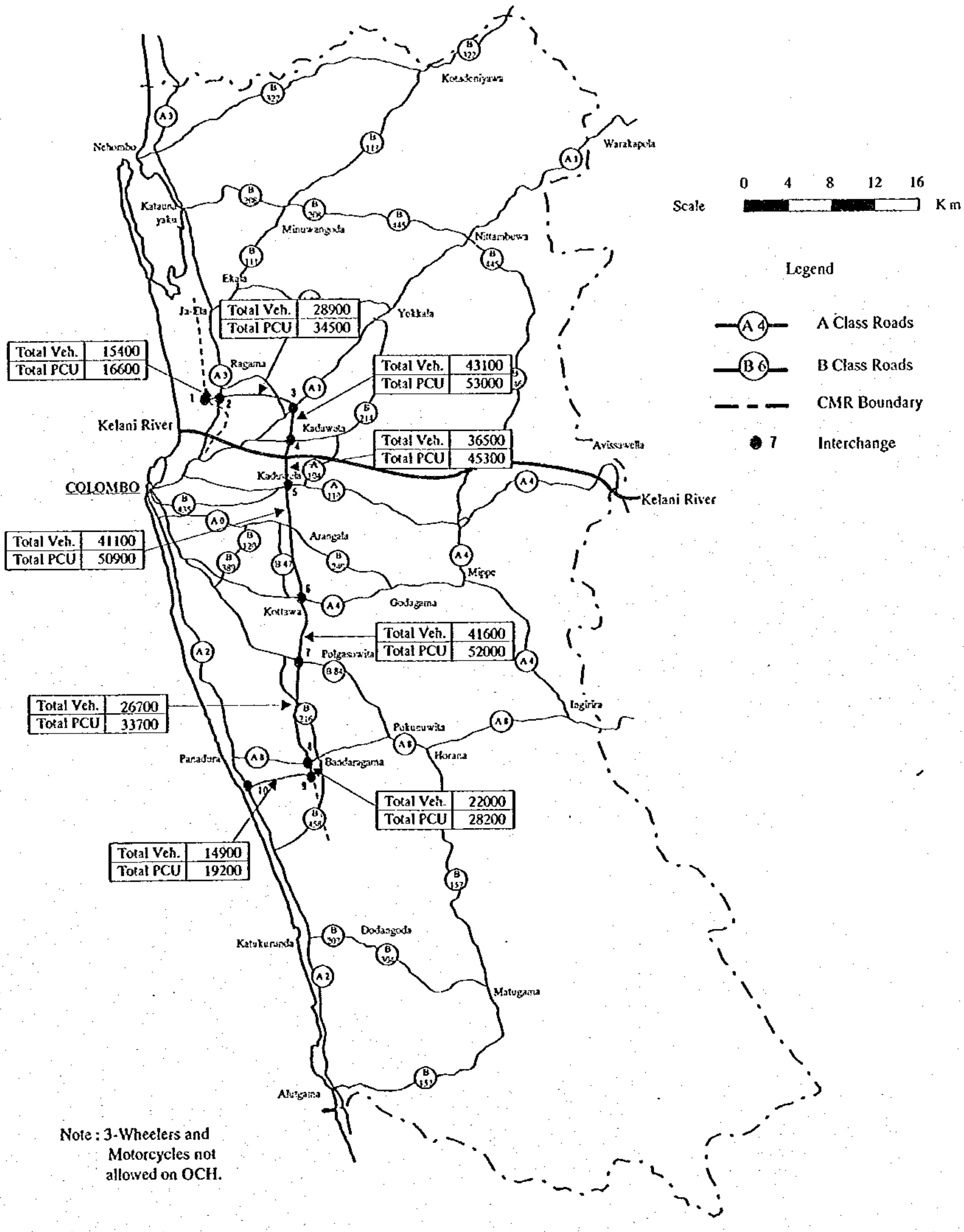


Fig. 5.31 Traffic Volume (both directions) for Road Links of Outer Circular Highway for 2010 for Most Appropriate Alignment

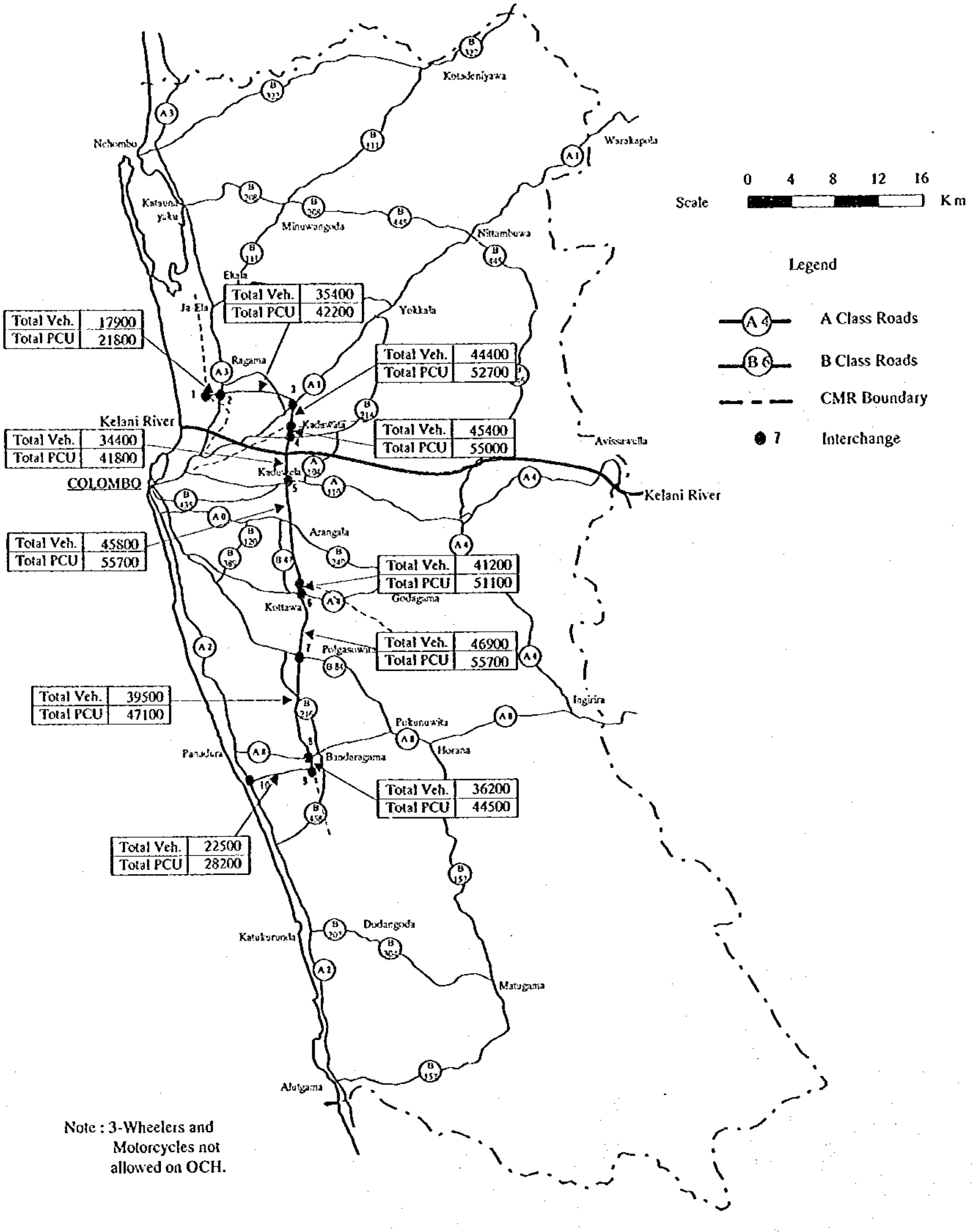


Fig. 5.32 Traffic Volume (both directions) for Road Links of Outer Circular Highway for 2020 for Most Appropriate Alignment

CHAPTER 6

ENGINEERING SURVEY

CHAPTER 6 ENGINEERING SURVEY

6.1 Aerial Photograph Survey

Only the Survey Department of Sri Lanka is to be allowed to carry out the aerial photograph survey in Sri Lanka. There are no private firms capable for carrying out this survey. The aerial coverage is approximately 40km in length and 10km in width and consists of about $545km^2$. Of these $545km^2$, approximately 30% have been carried out by the Southern Transport Corridor Project. The new aerial photographs which have been taken by the Survey Department, have been applied for further processing such as photo mosaics with a scale of 1/20,000, topographic mapping, and etc.,

6.1.1 Air Survey

1) Study Area

The Study area is in the Colombo Metropolitan Region(CMR) which is representative of the Western Province and consists of the three administrative districts of Gampaha, Colombo and Kalutara. Total (approx. area : $545km^2$)

2) Flight Period

Aerial Photograph survey has been carried out in February ,1999.

3) Flight Specification

The fright specification to be applied for the aerial photograph is as follows:

(1) Aircraft

- Aircraft : Ceisna 441C
- Camera : WILDRC20
- Lens : 15/4UAG-F ; forcal length : 153mm
- Filter : 450mm
- Film : Agfa Pan 200 PEI

(2) Specification

- Flight Altitude : 3,000m(M.S.L)
- Photography Scale : 1: 20,000
- Flight Courses : 8 lines (Southern Highway Project : 6 lines) Total 14lines
- Overlap : 60 %
- Side lap : 30%
- Crab : less than 10 degrees
- Tip & Tilt : less than 5 degrees

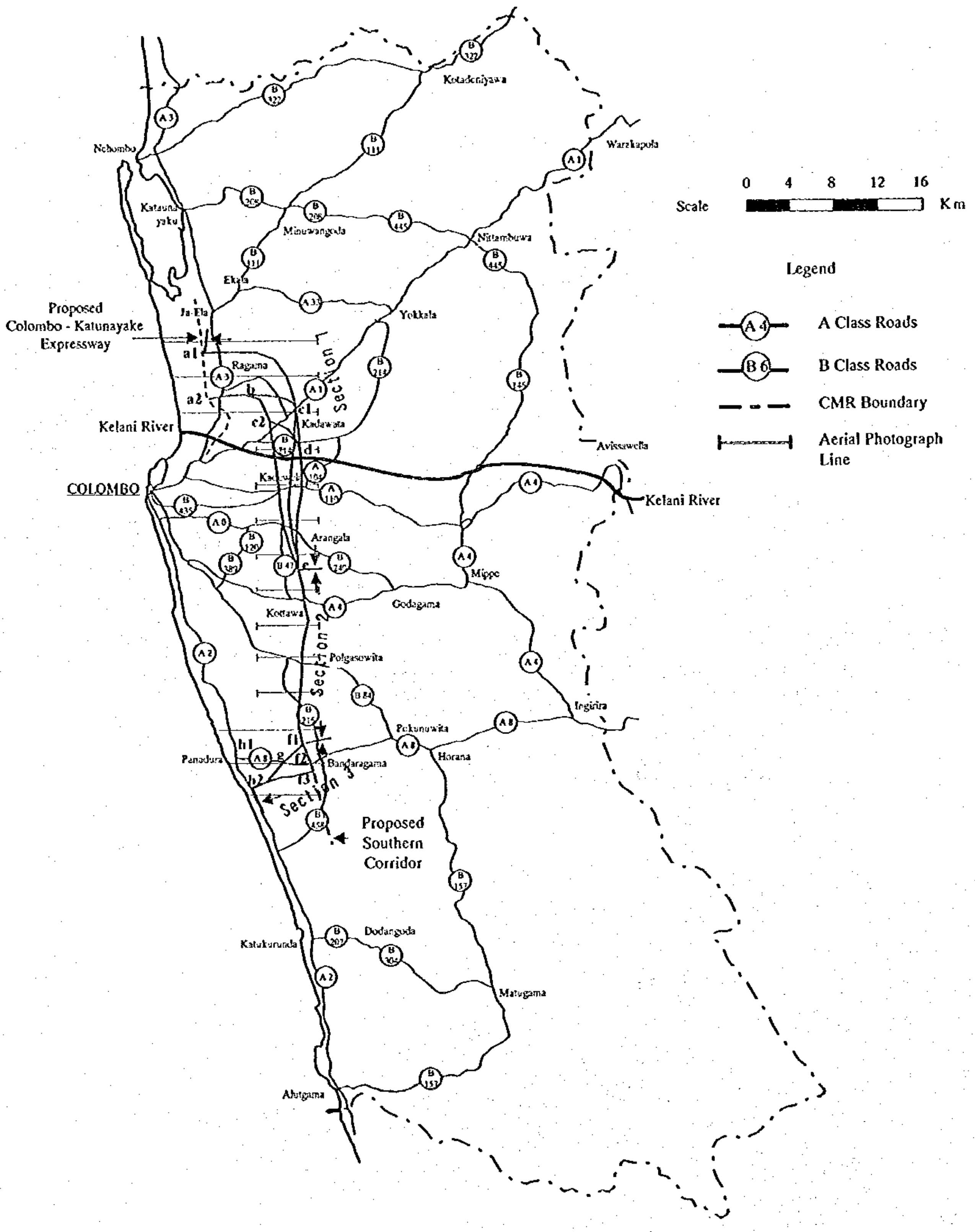


Fig 6.1 Orientation Map of Aerial Photograph

Area Coverage : approx.377km^2 (Southern Transport Corridor Project:168km^2)
Total 545km^2

The orientation map of aerial photograph is shown in Figure-6.1

4) Photo Processing

The photo processing has been carried out in the photo laboratory of the Survey Department and the photo processing equipment is shown as follows:

Film Processor : Agfa Graviton 66
Developer : Agfa G74C
Contact Printer : KG 30 printer
Picture Size : 23× 23cm

5) Digital Photograph Mosaic (Operation in Japan)

The aerial photographs were taken back to Japan for further processing upon the obtaining approval from the Ministry of Defense. The aerial photographs were digitized by scanning and were compiled as photograph mosaic data in the following manner :

(1) Scanning and digitalization of aerial photographs
The aerial photographs are scanned with resolution of 800 dpi.

(2) Digital Mosaic
Digital photograph data are retrieved and shown on screen, and the photograph images are connected one by one.

(3) Compilation and Original Mosaic
Mosaic sheets are arranged according to the index map. Major roads and rivers are annotated on the monitor as original mosaic data. Original mosaic data are compiled by providing marginal information, such as photograph mosaic scale, sheet number, adjoining sheet map and north direction.

(4) Output
Final results are produced by laser plotter at 800 dpi. resolution

(5) Main Equipment to be used
Software : ER Mapper 5.2
Scanner : UMAX ; Mirage II , CPU; Pentium 150, Hard disk, 2.5GB
Computer : CPU ; Pentium 233(RAM 64 MB), Hard disk, 6 GB
Laser Plotter : Lightjet 5000

6.1.2 Creation of Digital Photo-Mosaics for Route Selection

In order to examine and determine concrete routes, previous aerial photos were used to create photo-mosaics. Colour tone variations between photos were corrected, and the photo-mosaics were digitised in order to optimise them for route selection.

The digital photo-mosaics created were as follows:

* Scale of 1:20,000 1 set
* Scale of 1:120,000 1 set

The planned routes were represented on the 1:20,000-scale digital photo-mosaic. The necessary geographic names were indicated on the 1:120,000-scale digital photo-mosaic.

6.1.3 Ground Survey

The ground survey consisted of photo control survey, levelling, cross section survey and field survey, and was conducted in accordance with the following work quantities and specifications:

* Photo control survey

Work quantity:	16 points	
Specifications:	Method	Static relative positioning using GPS
	Equipment used	Single- or dual-frequency GPS receivers
	Observation time	A minimum of 1 hour
	Number of observed satellites	A minimum of 4 satellites
	Others	Linked to other control points

* Levelling

Work quantity:	94 km (installation of 10 bench marks)	
Specifications:	Method	Junction or reciprocal observations
	Equipment used:	Auto-level
	Observation distance	Less than 80m
	Interval between pricking points	200 ~ 400m
	Closing error	50 mm $\sqrt{S}$ (S = Route length in km)

* Cross section survey

Work quantity:	3 sections (Kelani Ganga)	
	3 sections (Bolgoda Ganga)	
Specifications:	Plotting scale	H = 1:500, V = 1:200

* Field survey

Work quantity: 50 km^2

① **Photo Control Survey**

The control points necessary for aerial triangulation and plotting were selected and pricked on the aerial photos. Piles were installed in the field.

After installing piles at each control point, GPS observations with 5 satellites were conducted for at least 1 hour using 5 GPS receivers.

② **Levelling**

Levelling routes were decided based on aerial photos and field reconnaissance, and new bench marks were installed at the necessary points. Levelling was conducted along the routes planned, based on existing bench marks. Pricking locations were chosen at clear landmarks on the aerial photos. Then, the elevations of control points located on or near the planned routes were measured.

③ **Cross Section Survey**

The river cross section survey was conducted for a total of 6 sections in 2 areas. GPS control points and newly established bench marks were used as standards for horizontal positions and vertical positions respectively. The cross section survey necessarily included the observation of critical points (change of slope). The acquired digital data were plotted (represented) at the specified scale using computer software.

④ **Field Survey**

Information necessary for the representation of topography but not obtainable by photo-interpretation were identified in the field, and the results were indicated on the photos in view of digital plotting and digital compilation operations. Administrative names and boundaries were decided based on the collected 1:50,000 and 1:10,000 topographic maps.

6.1.4 Photogrammetry

① **Aerial Photogrammetry**

Aerial photogrammetry entailed determining pass point coordinates for each model, as they were necessary for subsequent digital plotting operations. The bundle adjustment method was used for this calculation. The residual mean square errors at each control point, which show the accuracy of the results, were good, at 0.211 m (horizontal position) and 0.364 m (vertical position).

Work quantity:	13 lines, 57 models
Adjustment method:	Bundle adjustment method

Comparator: Stecometer

② **Digital Plotting**

Topographic and planimetric features were digitally plotted, using aerial photogrammetry and field survey results. A special code was assigned to each topographic and planimetric feature to ensure the advanced use of data obtained.

Work quantity:	1:2,000	10.06 km^2
	1:5,000	40,74 km^2
Equipment used:	Analytical plotter DSR14, SDR2000	

③ **Digital Compilation**

Digital compilation was carried out using the data obtained by digital plotting and the field survey results, and in accordance with map symbol specifications. The data obtained by digital compilation were saved into plot files and DGN files.

Work quantity:	1:2,000	10.06 km^2
	1:5,000	40,74 km^2
Software used:	MicroStation 95	

④ **Output**

The plot files created by digital compilation were output at the specified scale and in accordance with the map symbol specifications. Paper-base colour printouts as well as film-base laser printouts were prepared.

Work quantity:	1:2,000	11 sheets
	1:5,000	15 sheets

6.2 Natural Conditions Survey

6.2.1 Work in Sri Lanka

The JICA study team conducted studies on literatures and existing data and field survey during a period from January to February 1999 mainly in terms of the following items:

(1) Geological and topographical surveys along the route

(2) Collection of existing boring data, etc. on the study area from RDA and other sources

(3) Topographical study on alternative routes along with the field survey result based on the 1/50,000 and 1/10,000 topographic maps leased from the Survey Department of Sri Lanka

The review was made on the basis of above investigation results concerning (a) prediction of flood run-off through the valley topography that crosses the route, (b) investigation on the borrow pits in the neighborhood of the route to soil availability in terms of the topography and geology, etc.

From May to July, 1999, the JICA study team contracted the following natural conditions survey to a local research company to ensure the accuracy of outline design concerning the optimum route selected for detailed study. The Team was in charge of planning and supervision of the study.

(4) Geotechnical investigation and collection of hydrological data

Survey items		Work quantity		
Mechanical boring (land section)		8 points	Total of boring length	112 m
ditto	(river section)	5 points	ditto	53m
ditto	(marsh section)	2 points	ditto	30m
			Grand total of boring length	195m

Undisturbed soil sampling (fixed piston sampler)			17samples
Standard penetration test (each 1m)			132numbers
Portable cone penetration test (Machintosh test)		points Total of penetration length	23m
Field CBR test		8points	16numbers
Compaction test of disturbed soil (Proctor) and CBR test		17points	17numbers
Undisturbed CBR samples and CBR test		17points	17numbers
Soil test in laboratory:	Particle size distribution		142samples
	Specific gravity		156samples
	Atterberg test (liquid limit and plastic limit)		39samples
	Ignition loss		20samples
	Unconfined compression test		44samples
	Consolidation test		39samples

Collection of hydrological data

Max. flood run-off study data for crossing points of Kelani and Bolgoda Rivers.

Daily rainfall data (1974 – 1999):

Angoda, Bandaragama and Horana monitoring observatories

Source: Department of Meteorology

Mean daily flow (1972 – 1998): Hanwella observatory (Kelani River)

Source: Department of Irrigation

Flood stage along the route (Interview with local residents)

6.2.2 Topography

The route is mostly planned in the inland, that is, in the hilly topography around Colombo about 5 – 15 km from the coast. Only the start point (near the route A3 at a junction with the Colombo Katunayake Expressway in the north) and end point (near junction with the national road A2 in the south) are located in the littoral alluvial lowland near the coast. The hilly topography includes undulating hills with an elevation of 10 – 35 m or less that consists of pre-Cambrian bedrock and its weathered soil and the alluvial lowland developing along dendritic water systems (valleys, morass, streams) where flood plain sediments (sand, silt, clay, gravel) originating from weathered soil were deposited dissecting the hills.

The route crosses two water systems. The system portion that is to the north and central section of the route runs off into Kelani River while the portion to the south runs off into Bolgoda River and lake, both via the dendritic water system.

In the inland area along the selected route, the hills with the elevation of 5 – 10 m or more have the wide-ranging housing area and coconut plantations and various crop fields. Namely, this is a land already developed for high-level utilization. Therefore, the alignment employed for the route is to pass through the boundary between the hill slope end and the lowland, swamp (with the elevation of less than 5 – 15 m) used for the paddy along the stream and flat paddies.

On the other hand, the topography from the area near the coast at start and end points of the route facing the Indian Ocean ranges from the coastal alluvial lowland to backland swamp with the elevation of 0 – 5.6 m or less. Except for the area along the national highway, most of the lands are either unused or used only partially.

As a whole, the optimum route will have an alignment to pass the unused lowland and low swamp. Fig. 6.2.1 shows the percentage of elevation at which the center line of optimum route passes. It is found that 70% of the entire route passes through the land where the elevation is 10 m or less.

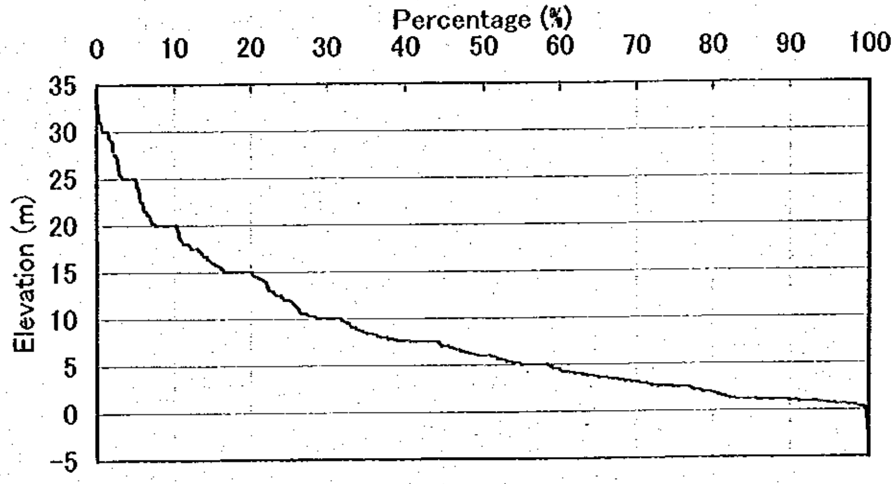


Fig-6.2.1 Elevation distribution of Longitudinal profile

The topography is classified as follows along the station (STA) of the optimum route:
(STA indicates the distance from the junction of CKE which are on the Preliminary Drawings)

(1) CKE (Colombo Katunayake Expressway) – A1 Road

STA -7 – STA6: Alluvial lowland with the elevation ranging from 0 to 5 m

STA6 – STA16: Hilly topography with the elevation of 5 m

STA16 – STA43: Peat land of backland swamp with the elevation of 0 m

STA43 – STA53: Crossing ridges of the hilly topography with the elevation ranging from 10 to 30 m

STA53 – STA62: Passing through paddies in the dendritic system with the elevation ranging from 2 to 5 m

STA62 – STA77: Hilly topography with the elevation ranging from 20 to 30 m

STA77 – STA82: Passing through paddies in the dendritic system with the elevation of 10 m

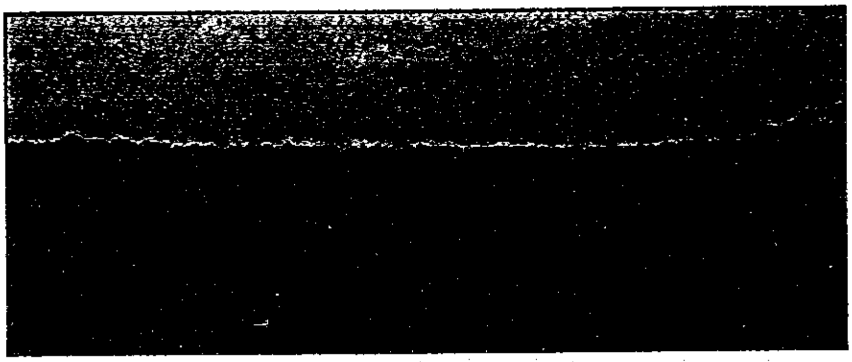


Photo 6.2.1 Boggy area at Nawanmehara Marsh : near STA24

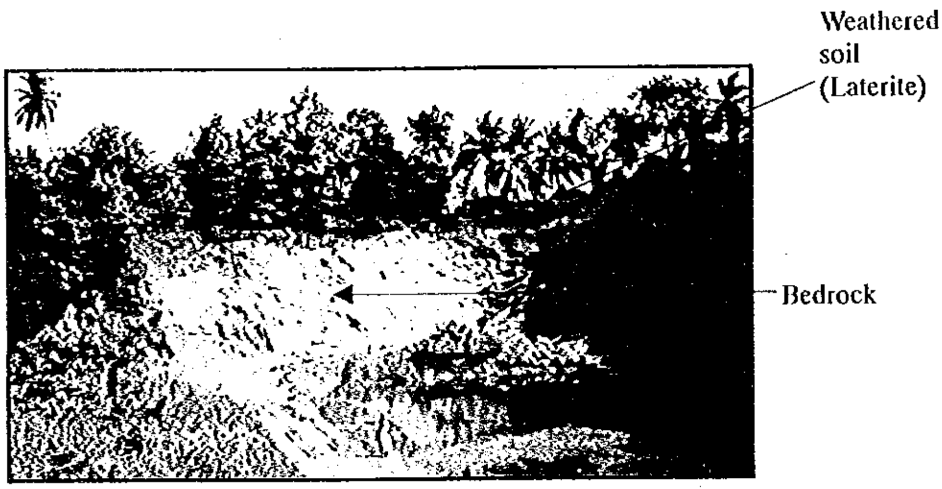


Photo 6.2.2 Old Rock Quarry at Ihara Karagahamura : near STA70

(2) A1 Road – A4 Road

STA82 – STA90: Passing through paddies in the dendritic system with the elevation of 10 m

STA90 – STA96: Crossing ridges of the hilly topography with the elevation ranging from 15 to 25 m

STA96 – STA98: Passing through paddies in the dendritic system with the elevation of 8 m

STA98 – STA104:	Crossing ridges of the hilly topography with the elevation ranging from 15 to 25 m
STA104 – STA108:	Passing through paddies in the dendritic system with the elevation of 10 m
STA108 – STA115:	Hilly topography with the elevation ranging from 15 to 35 m
STA115 – STA121:	Valley in the hilly topography with the elevation of 10 m
STA121 – STA123:	Passing through paddies in the dendritic system with the elevation of 15 m
STA123 – STA126:	Hilly topography with the elevation ranging from 10 to 15 m
STA126 – STA136:	Paddies in the dendritic system with the elevation ranging from 2 to 3 m
STA136 – STA138:	Crossing ridges of the hilly topography with the elevation ranging from 10 to 15 m
STA138 – STA140:	Passing through paddies in the dendritic system with the elevation ranging from 2 to 3 m
STA140 – STA147:	Hilly topography with the elevation ranging from 10 to 18 m
STA147 – STA151:	Passing through paddies in the dendritic system with the elevation ranging from 2 to 5 m
STA151 – STA154:	Hilly topography with the elevation ranging from 5 to 10 m
STA154 – STA160:	Backland with the elevation ranging from 1 to 3 m. Former laterite borrow pit
STA160 – STA163:	Kelani river and its bank topography.
STA163 – STA167:	Hilly topography with the elevation ranging from 5 to 8 m.
STA 167 – STA174:	Lowland in the dendritic system with the elevation ranging from 3 to 4 m
STA174 – STA177:	Hilly topography with the elevation ranging from 5 to 15 m.
STA 177 – STA181:	Paddies and hills in the dendritic system with the elevation ranging from 5 to 6 m
STA181 – STA187:	Hilly topography with the elevation ranging from 15 to 25 m.
STA 187 – STA192:	Paddies and hills in the dendritic system with the elevation ranging from 3 to 4 m
STA192 – STA198:	Hilly topography with the elevation ranging from 15 to 20 m.
STA 198 – STA199:	Passing through paddies in the dendritic system with the elevation of 10 m
STA199 – STA207:	Hilly topography with the elevation ranging from 15 to 20 m.
STA 207 – STA208:	Passing through paddies in the dendritic system with the elevation of 8 m
STA208 – STA211:	Hilly topography with the elevation ranging from 15 to 20 m.

STA211 – STA237: Paddy boundary in the dendritic system with the elevation ranging from 5 to 10 m

STA237 – STA243: Hilly topography with the elevation ranging from 10 to 22 m.

STA 243 – STA245: Passing through paddies in the dendritic system with the elevation of 15 m

STA245 – STA250: Hilly topography with the elevation ranging from 20 to 30 m.

STA 250 – STA277: Paddies in the dendritic system with the elevation ranging from 10 to 18 m

Photo 6.2.3 Topographic view of paddy and low hills around STA90

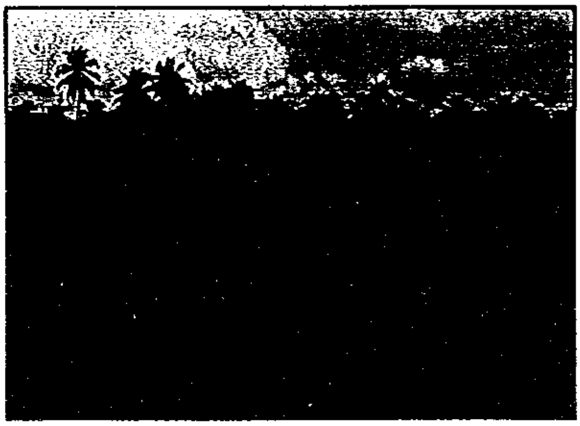


Photo 6.2.4 Kelani river at STA161

Photo 6.2.5 A view on A4 road at STA277 toward Colombo

(3) A4 Road – Southern Connection

STA277 – STA320: Paddies in the dendritic system with the elevation ranging from 5 to 10 m

STA320 – STA359: Paddies in the dendritic system with the elevation ranging from 3 to 5 m

STA359 – STA365: Hilly topography with the elevation ranging from 10 to 20 m.

STA365 – STA372: Paddies in the dendritic system with the elevation ranging from 2 to 4 m

STA372 – STA377: Paddies in the dendritic system with the elevation ranging from 5 to 10 m

STA377 – STA387: Hilly topography with the elevation ranging from 10 to 25 m.

STA387 – STA389: Paddies in the dendritic system with the elevation of 5 m

STA389 – STA393: Paddies and hills in the dendritic system with the elevation ranging from 10 to 22 m

STA393 – STA401: Hpaddies in the dendric system with the elevation ranging from 2 to 4 m

STA401 – STA404: Crossing ridges of the hilly topography with the elevation ranging from 5 to 10 m

STA404 – STA413: Lowland swamp with the elevation ranging from 1 to 4 m on the bank of Bolgoda river

STA413 – STA416: Crossing ridges of the hilly topography with the elevation ranging from 5 to 6 m

STA416 – STA427: Lowland swamp with the elevation ranging from 1 to 4 m on the bank of Bolgoda river

STA427 – STA431: Crossing ridges of the hilly topography with the elevation ranging from 6 to 7 m

STA431 – STA434: Lowland swamp with the elevation ranging from 1 to 2 m on the bank of Bolgoda river

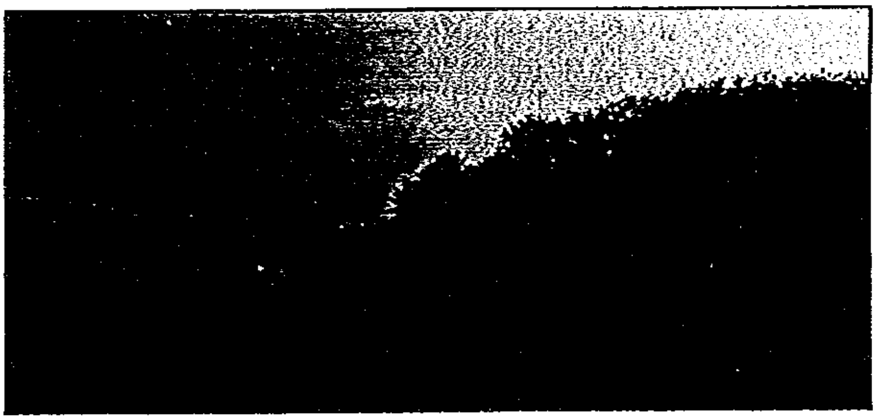


Photo 6.2.6 Topographic view of paddy and round hill at STA295

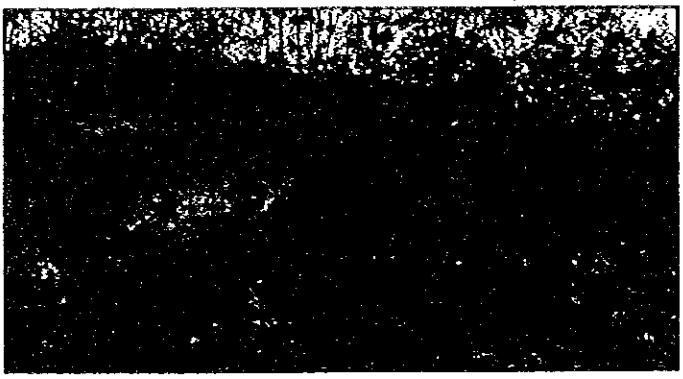


Photo 6.2.7 Representative cut of Laterite near STA330

(4) Southern Connection – A2 Road

STA434 – STA442: Lowland swamp with the elevation ranging from 0 to 1 m on the bank of Bolgoda river

STA442 – STA444: Bolgoda river and its bank topography.

STA444 – STA450: Lowland swamp with the elevation ranging from 1 to 2 m on the bank of Bolgoda river

STA450 – STA453: Crossing ridges of the hilly topography with the elevation ranging from 2 to 3 m

STA453 – STA458: Lowland swamp in the dendritic system with the elevation ranging from 1 to 2 m

STA458 – STA460: Crossing ridges of the hilly topography with the elevation ranging from 2 to 3 m

STA460 – STA469: Lowland swamp in the dendritic system with the elevation ranging from 1 to 2 m

STA469 – STA475: Crossing ridges of the hilly topography with the elevation ranging from 3 to 8 m

STA475 – STA492: Lowland swamp with the elevation ranging from 1 to 2 m on the bank of Bolgoda lake

STA492 – STA506: Alluvial lowland with the elevation ranging from 3 to 6 m

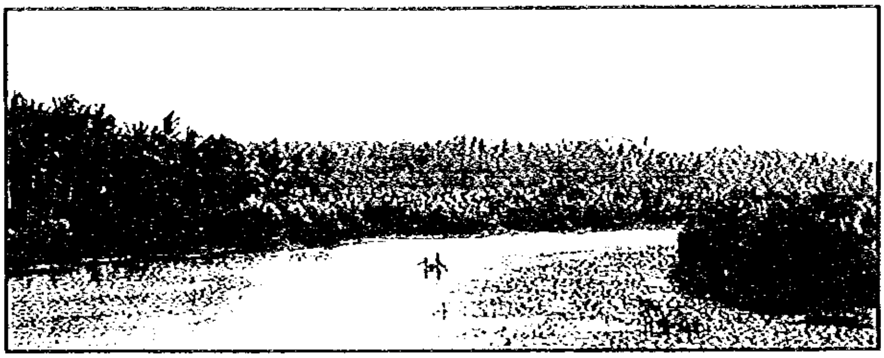


Photo 6.2.8 Bolgoda river near STA443

Photo 6.2.9 Topographic view of low hill and low land near STA460

6.2.3 Geology

Lowlands (paddies) and valley with the elevation of 10 m or less, which account for 70% of the inland route, have flood plain deposit. The deposit ranging from 1 -- 2 m under the ground is mostly soft clayey soil to loose sandy soil with relatively uneven grain size. Peat and organic clayey soil may often intervene thinly in the above flood plain deposit layer, but are distributed mainly in backland marsh or swamp. In the swamp near STA24, thick deposit of peat was confirmed on the route in this field survey.

In the hills along the route, there are cuts and quarries where bedrock outcrops. Generally, the ground is covered with reddish-colored laterite (weathered soil) to a thickness of several to more than 10 m. Bedrocks distributed in the project area include gneiss, charnokites, and granite, and the weathered to fresh portions of gneiss and granitic gneiss were confirmed during boring this time.

The field survey this time confirmed distribution mainly of sandy soil in the alluvial lowland near the coastal area (near start and end points). According to the existing data, a drowned valley and peat and clay layers of old backland marsh intervene in certain areas. The lower weathered bed rock is covered to a thickness of several meters to more than 10 m with the peat in the backland marsh observed in many points of the area from start and end points and with the alluvial layer comprising sandy, gravely, and clayey soils in the lowland in the dendritic water system. It appears from data obtained through boring and analysis of existing data that the peat which is soft and may present problem for road construction will not exceed 10 m in layer thickness.

Photo 6.2.10 Varying thickness of Laterite covering the base rock, near STA70

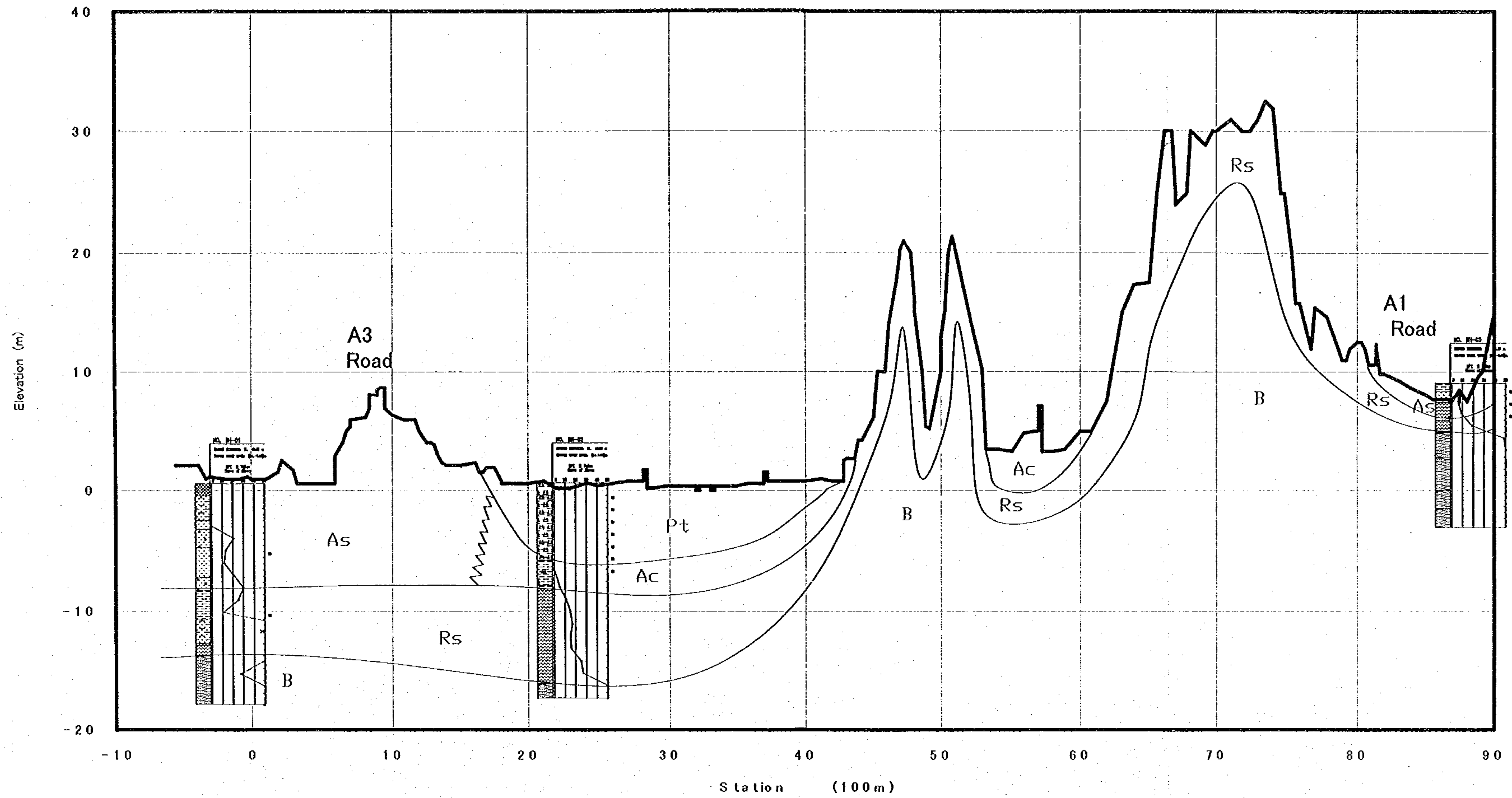


Fig.6.2.2 Geological cross section (Provisional)
(Section : Katunayake Expressway to A1 Road)

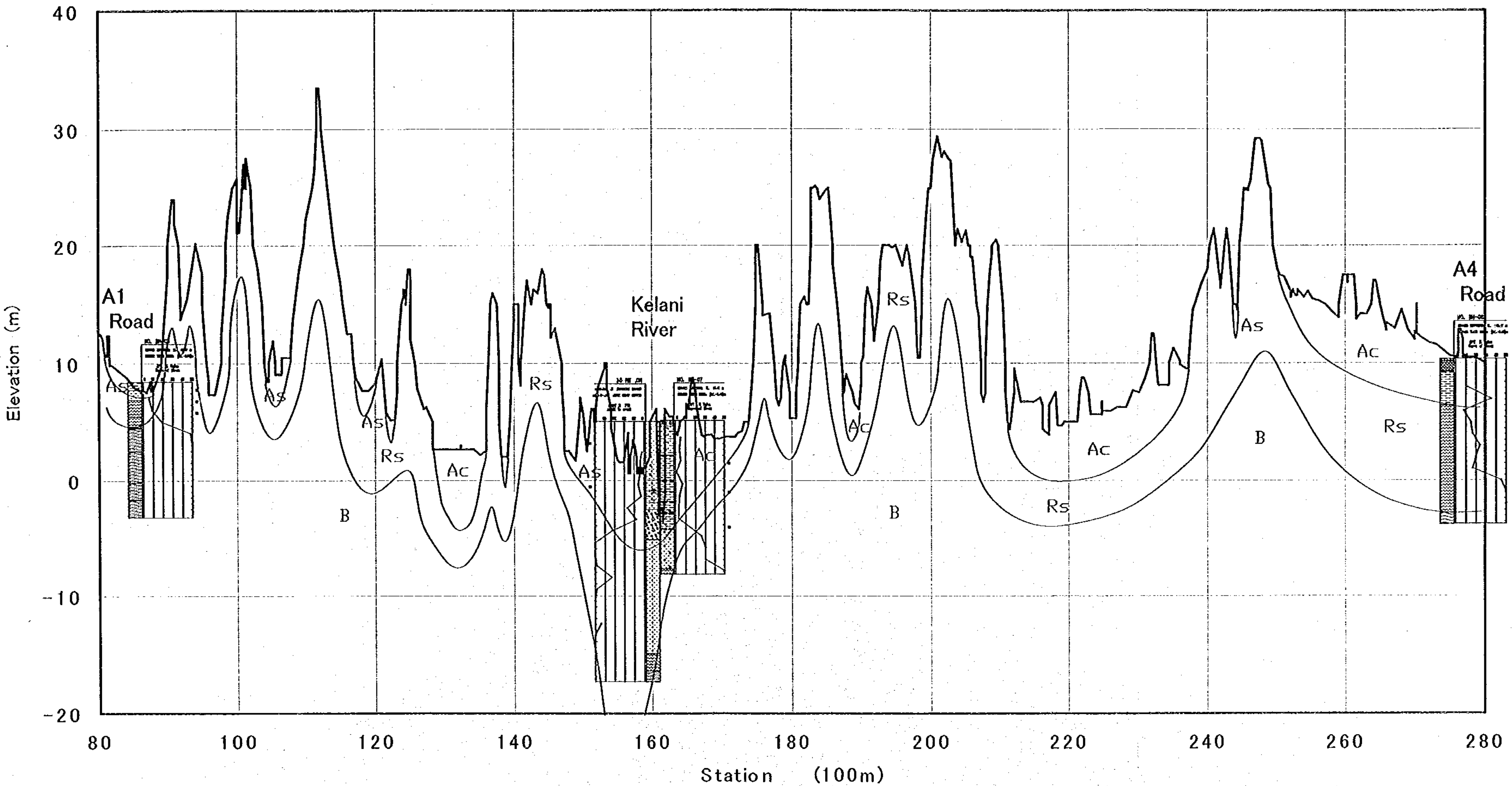


Fig.6.2.3 Geological cross section (Provisional)
(Section : A1 Road to A4 Road)

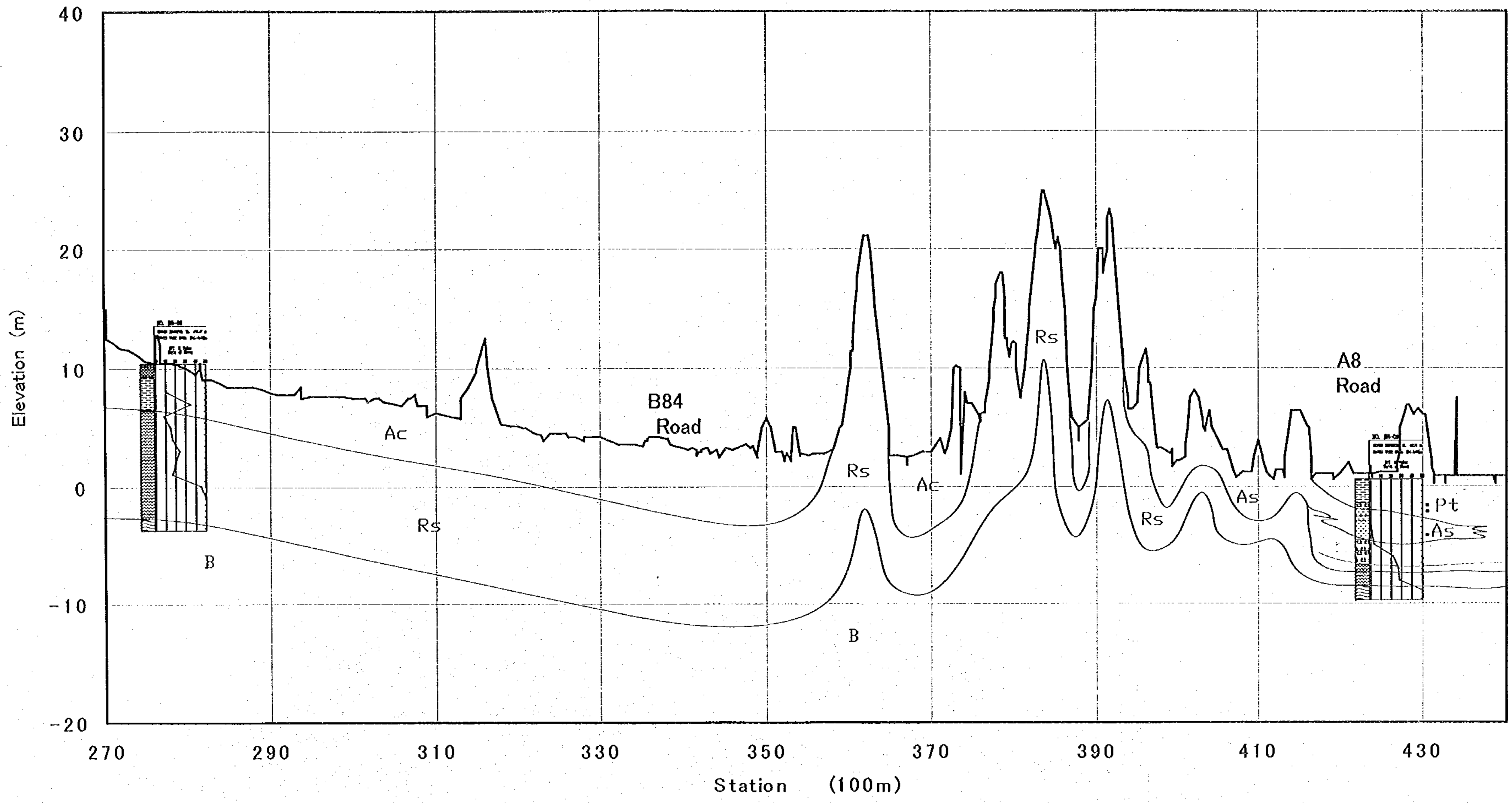


Fig.6.2.4 Geological cross section (Provisional)
(Section : A4 Road to Southern connection)

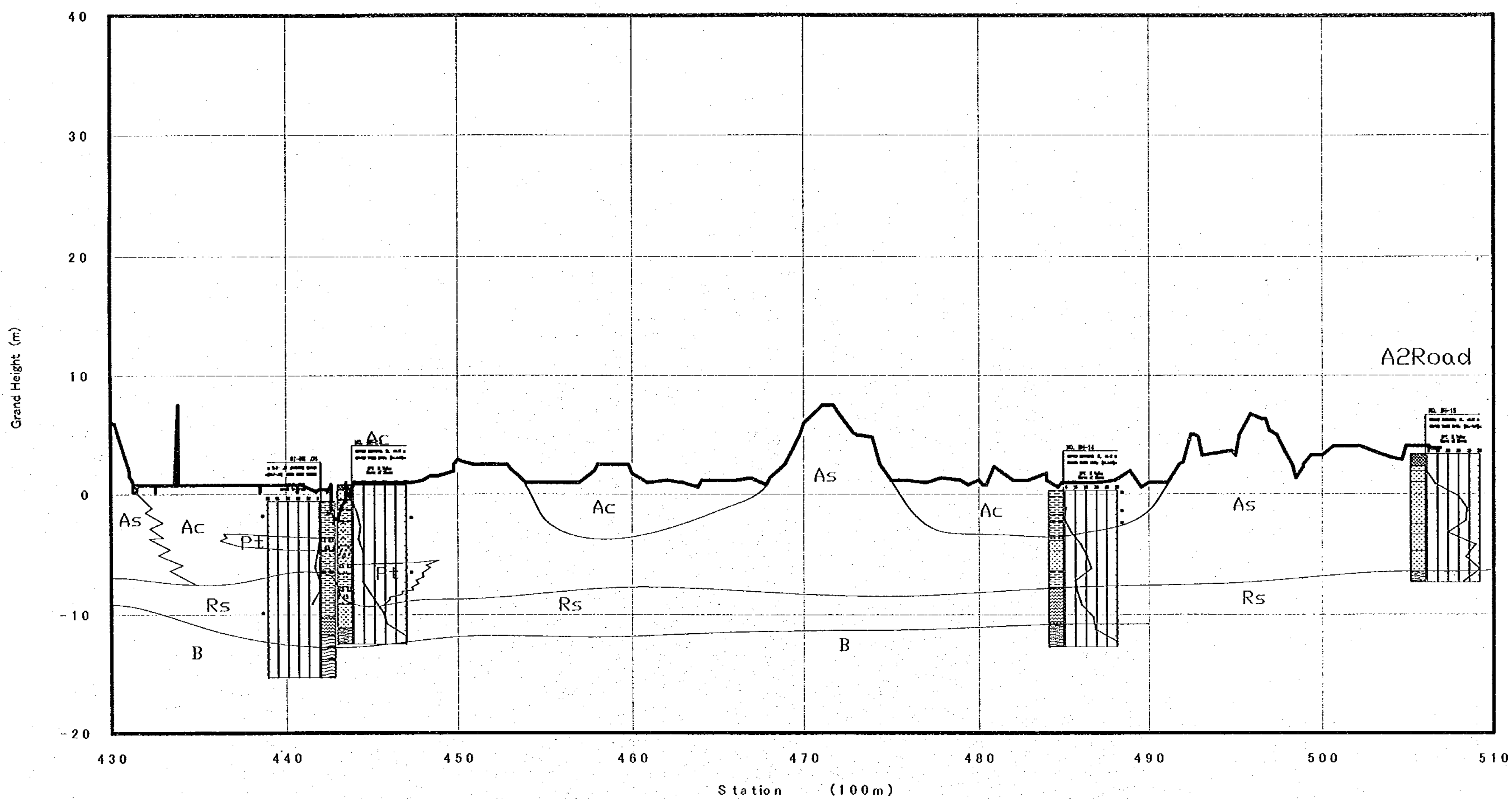


Fig.6.2.5 Geological cross section (Provisional)
(Section : Southern connection to A2 Road)